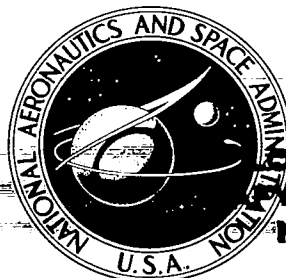


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COMPUTER USER'S GUIDE FOR A CHEMICALLY REACTING VISCOUS SHOCK-LAYER PROGRAM

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ABSTRACT

The present report describes the computer code for predicting viscous shock-layer flows over nonanalytic blunt bodies (Program VISLNABB) for hyper-sonic, low Reynolds number flows.

Two specific and one general body geometries are considered. Program options are for two-dimensional or axisymmetric flow over hyperboloids, paraboloids and geometries defined in tabular form. Details of the theory and results are included in a separate engineering report. The program, subroutines, variables in common and input and output data are described. A summary of the theory, listings of input and output data for four sample cases and a program listing are given in appendices.

TABLE OF CONTENTS

ABSTRACT	ii
TABLE OF CONTENTS	iii
LIST OF FIGURES	vii
INTRODUCTION	1
DESCRIPTION OF PROGRAM	2
MAIN Routine	3
Subroutine DERIV3	7
Subroutine ENERGY	7
Subroutine GEOM	8
Subroutine HCP	8
Subroutine HCPA	9
Subroutine INTERP	9
Subroutine INTER3	9
Subroutine INTRPS	10
Subroutine INTRP3	10
Subroutine MASS	10
Subroutine NMOMNT	11
Subroutine RESET	11
Subroutine RTEDTA	12
Subroutine SET	12
Subroutine SET2	13
Subroutine SHVALS	13
Subroutine SMOMNT	13
Subroutine SMOOTH	14

Subroutine SMTHPR	14
Subroutine SOLVE	14
Subroutine SPECIE	15
Subroutine THERM	15
Function TLU	16
Subroutine VISCNA	16
Subroutine VISCON	17
Subroutine VPRFLE	17
Subroutine WISUB	17
Subroutine BLOCK DATA	18
DESCRIPTION OF VARIABLES IN COMMON	19
DESCRIPTION OF INPUT DATA	32
Data Input in MAIN	32
Data Input in Subroutine RTEDTA	33
Data Input in Subroutine GEOM	34
Input Data in NAMELIST INPUT	35
PREPARATION OF INPUT DATA	38
Minimum Input Data Required	38
Shock Shape Data Input	38
Surface Temperature Input Data	39
Input of Body Geometry Data	39
Variable Values for Specific Conditions	39
DESCRIPTION OF OUTPUT DATA	41
Unit 6 Output	41
Unit 1 Output	45
Unit 3 Output	45

Unit 8 Output	46
Unit 9 Output	47
Unit NTPL Output	48
APPENDIX A: ANALYSIS	49
Governing Equations	49
Boundary Conditions	58
Surface Transport	60
Thermodynamic and Transport Properties	61
Chemical Reaction Model	63
Method of Solution	65
Solution of S-Momentum, Energy and Species Conservation Equations	66
Solution of Y-Momentum and Continuity Equations	69
Solution Procedure	72
List of Symbols	74
APPENDIX B: SAMPLE CASES	77
Job Control Language for the 140B Orbiter Sample Cases	77
Job Control Language for the 31° Hyperboloid Sample Cases	78
Reaction Rate Input Data for all Sample Cases	79
Body Geometry Input Data for the 140B Orbiter Sample Cases	80
Shock Shape Input Data for the 140B Orbiter Sample Cases	84
Unit 5 Input Data for the 140B Orbiter Binary-Gas Sample Case	88
Unit 5 Input Data for the 140B Orbiter 7-Species Sample Case	89
Shock Shape Input Data for the 31° Hyperboloid Sample Case	90
Unit 5 Input Data for the 31° Hyperboloid Binary-Gas Sample Case	94
Unit 5 Input Data for the 31° Hyperboloid 7-Species Sample Case	95

Listing of Unit 6 Output Data for the 140B Orbiter Binary-Gas Sample Case	96
Listing of Unit 6 Output Data for the 140B Orbiter 7-Species Sample Case	103
Listing of Unit 6 Output Data for the 31° Hyperboloid Binary-Gas Sample Case	113
Listing of Unit 6 Output Data for the 31° Hyperboloid 7-Species Sample Case	120
APPENDIX C: FORTRAN IV PROGRAM	131
List of Common Statements	131
Occurrence of Common Statements by Subroutines	132
Listing of PROGRAM VISLNABB	134

LIST OF FIGURES

Figure		Page
1	Flow Diagram of Program VISLNABB by Function	4
2	Flow Diagram of Program VISLNABB by Subroutines Called	5
3	Coordinate System for Viscous Shock-Layer Flow over Blunt Bodies	50
4	Schematic of Finite-Difference Grid System	67

FOREWARD

Reports Hypersonic Ionizing Air Viscous Shock-Layer
Flows Over Nonanalytic Blunt Bodies (CR-2250) and Computer
User's Guide For a Chemically Reacting Viscous Shock-Layer
Program (CR-2251) by Miner and Lewis should be used
together as source or reference material.

INTRODUCTION

The computer code described in this report has been developed to predict hypersonic, low Reynolds number flows over nonanalytic blunt bodies. The program uses an implicit finite-difference method to solve the partial differential equations governing the viscous shock-layer flow. Two nonequilibrium gas chemistry models are included in the program. The first is for dissociating oxygen and the second is for ionizing, multicomponent air.

The viscous shock-layer method has several significant advantages over conventional boundary-layer methods. First, the flowfield is computed from the body to the shock and viscous effects need not be confined to a thin flow regime near the body. Second, effects such as entropy-layer swallowing and displacement-thickness interaction are avoided. Also, there is no need for any procedure to track streamlines from the shock crossing point to a boundary-layer edge. Third, the viscous shock-layer method, especially when shock slip is included, is applicable to much lower Reynolds number flows than boundary-layer methods are.

The principal purpose of this report is to describe the computer code in sufficient detail to allow a user to use the program and to properly interpret the solution data. Reasonable experience in using computer codes of this size is assumed as is some familiarity with the engineering aspects of the viscous flow problem.

The complete computer program is listed. Also listed are the output data for four sample cases and the required input data for these cases. All of the input variables are described as are the output variables for a converged station solution. All variables in common are described as are the variables in the subroutine or function argument lists. In the variable descriptions, a superscript * denotes a dimensional quantity. All other variables are nondimensional. Each subroutine or function is described in a separate subsection. As a further aid in using the program, an example is included of the Job Control Language needed to run the program on an IBM 370 computer. Also included are a list of all of the common statements and a listing of the occurrence of the common statements by subroutines. Finally, a section is included on preparation of input data with specific advice and suggestions.

Questions on the use of the computer program should be directed to the second author of this report (Dr. Clark H. Lewis) who was the principal investigator of contract NAS9-12630.

DESCRIPTION OF PROGRAM

Program VISLNABB is a Fortran computer program for predicting hypersonic, low Reynolds numbers, viscous shock-layer flows over nonanalytic axisymmetric or two-dimensional blunt bodies. The governing conservation equations follow the equations given by Davis for perfect gas or dissociating oxygen viscous shock layers but are extended to a more general chemistry; i.e. nonequilibrium, multicomponent air. The method of solution of the equations follows the procedure of Davis using an implicit finite-difference method.

Besides the more general flow chemistry, the present program differs from the methods of Davis in several important respects. First, the present method includes the general extension to nonanalytic, blunt bodies, where the methods of Davis were restricted to analytic blunt bodies such as hyperboloids and paraboloids. A second extension, required by the first, was the removal of the assumption that the shock and body angles were the same for the first global (TVSL) iteration. This assumption was quite good for the analytic, blunt bodies which Davis considered, but was unusable for some classes of non-analytic bodies. This assumption was removed by including the provision for an initial shock shape (and subsequent updating of the shock shape) which need not be the same as the body shape. For example, the shock shape might be obtained from a blunt body, method of characteristics procedure. A third extension was the inclusion of the provision for specifying a body geometry by tabular arrays.

The viscous shock-layer equations are principally parabolic in nature, but there is a dependence upon the downstream shock shape which introduces a slight elliptic nature of the governing equations. The equations are solved in a streamwise direction using a marching integration procedure. The elliptic nature is then satisfied with global iteration.

The dimensional, physical equations are first nondimensionalized by freestream and reference variables. The equations are then normalized by dividing the variables by the variable values behind the shock. The mass conservation (or continuity) and normal momentum equations are integrated using the trapezoidal rule. The streamwise momentum, energy and species conservation equations are of the standard parabolic form

$$W'' + A_1 W' + A_2 W + A_3 + A_4 W_s = 0$$

where W represents the dependent variable, the prime denotes differentiation with respect to η , (y/y_{sh}) , the subscript s denotes differentiation with respect to s and the A_i are the functions of the program variables. These equations are integrated by writing the equations in finite-difference* form and solving the resulting system of simultaneous algebraic equations.*

The first global iteration is for a thin viscous shock layer (TVSL) only. After the first global iteration is completed the shock data are updated and

*The solution procedure is discussed in Appendix A.

subsequent global iterations made for a fully viscous shock layer (FVSL) or for TVSL. A major function of the first global iteration is to refine the initial shock shape and to store v profiles on tape or disc. A considerable amount of computing time is saved by the first global iteration being for the binary gas (dissociating oxygen) and switching to the multicomponent air chemistry (if needed) after the first global iteration is completed. The data retained from global iteration to global iteration (the shock data and the v profiles) are largely chemistry independent.

The binary gas chemistry model has another advantage over the multicomponent gas chemistry model. The rate of production terms for dissociating oxygen are written in a form which allows a closer approach to equilibrium than possible for multicomponent air. For near-equilibrium flows it may be found that at the stagnation point a converged station solution is easily obtained for dissociating oxygen but a converged station solution can not be obtained for multicomponent air.

There is in the program no global iteration convergence criterion. For analytic bodies (e.g. hyperboloids) the second and third global iterations give nearly identical results. For some highly nonanalytic bodies, with the shock data averaging which is required, global iteration convergence may be neither practical nor fully possible. The second global iteration, however, will account for the major flow field effects of interest and may be considered adequate for most cases.

In the following subsections a brief description of each routine or subroutine will be given.

MAIN Routine

MAIN is the master routine of the program. In addition to controlling the overall computational flow of the program, MAIN initializes many of the program variables, reads much of the input data, calculates many of the program variables, and calculates the shock data for the next global iteration. Flow diagrams of MAIN by function and by subroutines called are given in Figs. 1 and 2.

The first function of MAIN is the initialization of counters and of some input/output unit numbers. The next function is the initialization of many of the NAMELIST variables, followed by reading of the NAMELIST INPUT and the readjustment of some of the variables. The next functions are the optional input of the shock shape data, the wall-temperature distribution and the s locations for specific solutions. The normal spacing of the finite-difference grid is next calculated and the reaction rate data are read by Subroutine RTEDA. This part of the program is performed only once for each calculation.

The global iterations begin after the comment "BEGIN MAIN LOOP." The shock shape data are optionally printed and variables are initialized for the beginning of each global iteration. The reaction rate constant and stoichiometric coefficient arrays are filled in Subroutine SET2. Freestream

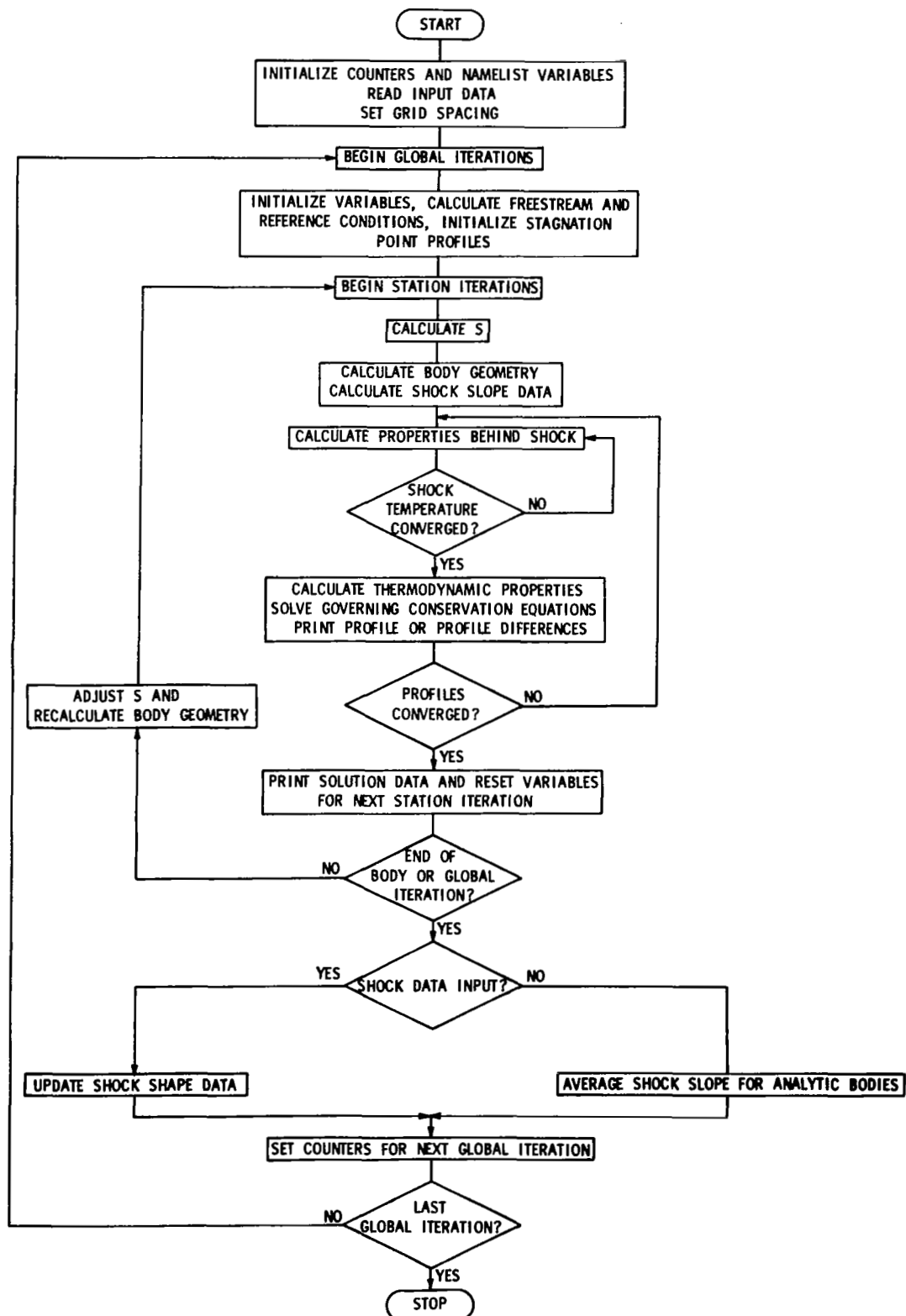


Fig. 1. Flow Diagram of Program VISLNABB by Function.

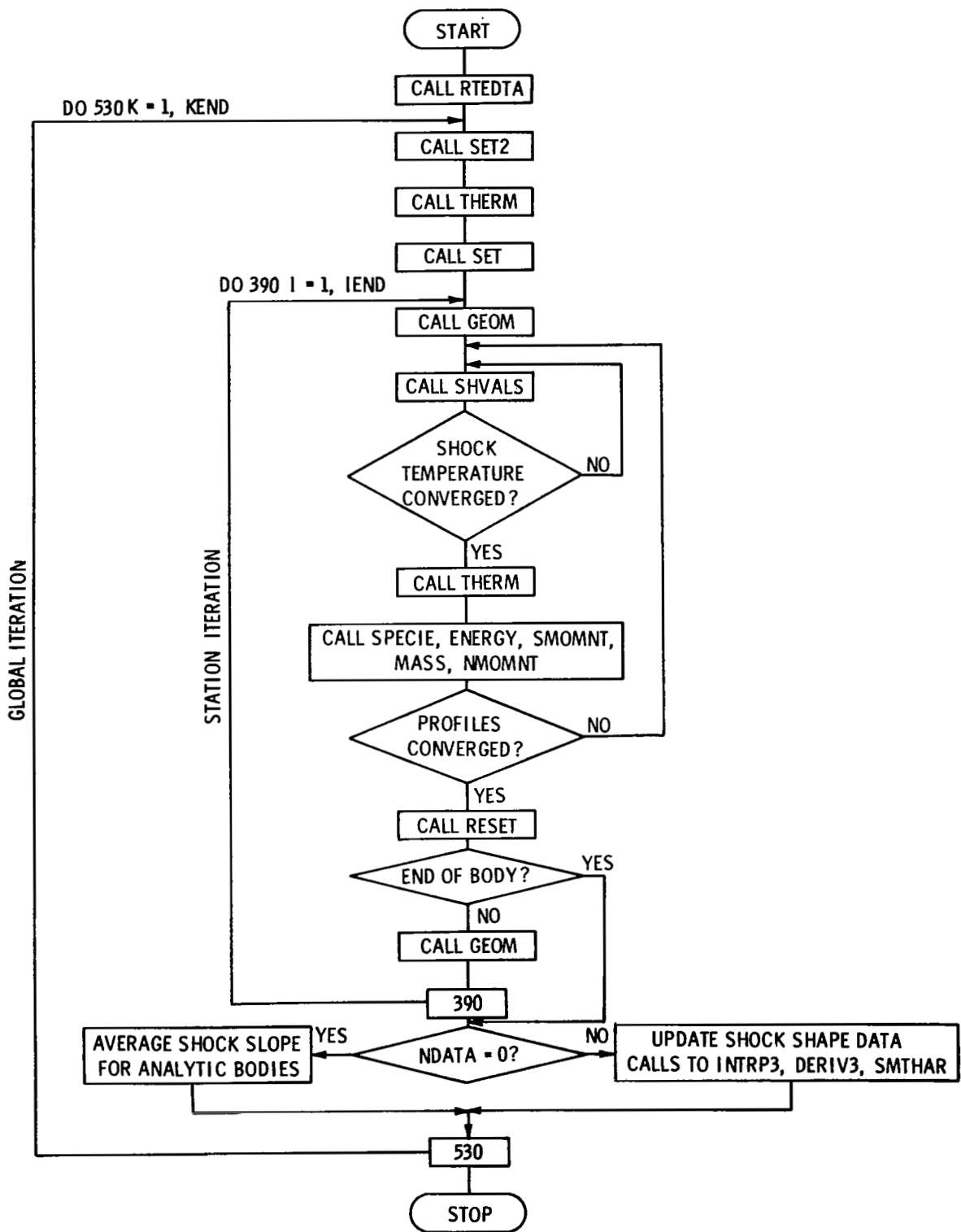


Fig. 2. Flow Diagram of Program VISLNABB by Subroutines Called.

and reference conditions are calculated in the first section of Subroutine THERM and profiles for the stagnation point are initialized in Subroutine SET. The global iterations are performed within a DO loop from 1 to KEND.

Following the comment "BEGIN SOLUTION ALONG BODY", a marching integration procedure is used for obtaining the station solutions. The station solutions are obtained within a DO loop from 1 to IEND. The wall temperature is optionally calculated and for a FVSL global iteration the v profiles from the previous global iteration are retrieved from disc by Subroutine VPRFLE. Subroutine GEOM returns the body angle, curvature and coordinates for $s + ds/2$. The shock angle and slope are calculated either by interpolation from the shock data arrays or from the body angle and shock-layer thickness.

Properties behind the shock are calculated by Subroutine SHVALS, which is called within an iteration loop requiring convergence of the shock temperature, TTS.

Subroutine THERM is called to provide the thermodynamic properties for the grid points of the shock layer. The governing conservation equations are solved by Subroutines SPECIE (the species equation), ENERGY (the energy equation), SMOMNT (the s momentum equation), MASS (the continuity equation) and NMOMNT (the y or normal momentum equation).*

Station iteration counters are then incremented. If PRNTCI = 1.0, the profiles (u/u_{sh} , T/T_{sh} and the C_i) with the species sums for O and N are printed. If PRNTCI = 0.0, only the maximum differences between the previous and present profiles are printed. The profiles are tested for convergence by comparing DIFI(I) with CNVRGI(I), ($I = 1, NSPL2$). All of the values of CNVRGI have been set to CONVRG except for CNVRGI for NO^+ which was set to $100 \times CONVRG$. The values of DIFI(I) are calculated in Subroutines SMOMNT ($I = 1$), ENERGY ($I = 2$), and SPECIE ($I = 3, NSPL2$) from the expression $DIFF = |1 - w/w_{last}|$, w is the present station iteration value of the profile at the grid point and w_{last} is the previous station iteration value. The maximum value of DIFF for the entire profile (at all grid points) is assigned to the appropriate DIFI(I).

If the convergence criteria are not met, another station iteration is performed (at s if NITER < NITMAX, or at $s - ds/2$ if NITER = NITMAX). If the convergence criteria are met, Subroutine RESET is called to print the station solution data and to reset the appropriate variables for the next station solution.

The step size DS is then adjusted (doubled if permitted or reduced to obtain a solution at a specific station), Subroutine GEOM is called to set the values of the body angle, curvature and coordinates and the program returns to the top of the station iteration loop unless the end of the

*See Appendix A for the governing equations.

station solutions for the global iteration has been reached (indicated by $I = IEND$ or by $S = SEND$).

After the stations solutions have been completed, four additional records are written on Unit NTW so that a subsequent eight point, least squares log-log curve fit will have an adequate number of points. The shock data for the next global iteration are then calculated. If $NDATA = 0$, only the derivative of the shock-layer thickness with respect to s , $XNSP$, is needed. The $XNSP$ array is smoothed by four consecutive averages over three points. If $NDATA \neq 0$, the shock-layer thickness derivative array, $XNSP$, is smoothed by four consecutive averages over three points. This averaging scheme is a modification of the simple arithmetic average used for $NDATA = 0$ and reduces to it if the solution points are equally spaced. The modification is for unequal point spacing and for three points on a straight line gives exactly the middle point. Three point Lagrangian interpolation is used to fill the $SHSLPN$ array from the smoothed $XNSP$ array.

After the shock data are calculated, the NTR and NTW files are rewound, the unit numbers are switched, and indicators are reset. The program then returns for another global iteration if $K < KEND$.

Subroutine DERIV3

Subroutine DERIV3 uses the first derivative of the Lagrangian interpolating polynomial of second order to calculate the first derivative of the function f at a point x . The equations for the interpolating polynomial are given in the description of Subroutine INTER3.

USAGE:

CALL DERIV3 (F, X, IMAX, IMIN, FP) where F and X are the arrays of the ordinate and abscissa values, IMAX and IMIN are the upper and lower subscripts of the arrays to be used, and FP is the array of the derivative of F with respect to X.

Subroutine ENERGY

The solution for the energy conservation equation is obtained by this subroutine. The coefficients of the energy equation in standard parabolic form, the A_j , are calculated first. The shock slip variables, $CS1$ and $CS2$, are next calculated and the wall conditions are set. The call to Subroutine SOLVE returns the new solution to the energy equation in the array $T2$ ($=T/T_{sh}$). The array $T1$ is the array of T/T_{sh} from the previous iteration ($s = 0.0$) or the previous station solution ($s > 0.0$). Negative points in the temperature profile are reset to a small positive number and T_{sh} is recalculated. If $s = 0$ the $T1$ and $R1$ arrays are updated. The TC and RC arrays are calculated at the average of the $T1$ and $T2$ and the $R1$ and $R2$ arrays. The $T21$ array, the previous station iteration $T2$ array, is compared with the present $T2$ array and the maximum of the expression

$$|1 - T2/T21|$$

is stored as DIFI(2) for the convergence test. The array T21 is reset and TCNW, the derivative of the TC array with respect to y, evaluated at the wall, is calculated. Program control then returns to MAIN.

USAGE:

CALL ENERGY

Subroutine GEOM

The body geometry data are calculated in Subroutine GEOM. Provisions are included for two specific geometries with a third geometry specified by a table of z, r and s coordinates. The first two sections of the subroutine are for paraboloids and hyperboloids respectively. These two analytic bodies have a continuous distribution of the surface curvature κ or CK.

The third section of the subroutine, on the first call, reads arrays of z, r, s, κ , and θ and for all calls returns the body coordinates, curvature and angle by interpolation in these arrays. The curvature might be calculated from the expression

$$\kappa = \left| \frac{d^2 r}{dz^2} \right| / \left[1 + \left(\frac{dr}{dz} \right)^2 \right]^{3/2}$$

which is equivalent to the alternate expression for curvature

$$\kappa = \left[\left(\frac{d^2 r}{ds^2} \right)^2 + \left(\frac{d^2 z}{ds^2} \right)^2 \right]^{1/2}$$

USAGE:

CALL GEOM (S, DS, RS, CK, CSF, SIF, XB) where S is the surface distance, DS is the increment in S, RS is the radial coordinate, CK is the curvature, CSF is the cosine of the local body angle, SIF is the sine of the local body angle and XB is the axial coordinate. S, DS and RS are passed to Subroutine GEOM and RS, CK, CSF, SIF and XB are returned. RS is recalculated by GEOM.

Subroutine HCP

Three point Lagrangian interpolation is used to calculate the species enthalpy and specific heats for one temperature TR which is passed to HCP. CPII, HII and HIFAC are returned.

USAGE:

CALL HCP (TR, CPII, HII, HIFAC) where TR is the temperature in °R, CPII is the array of the species specific heats, $C_{p_i}^*$, (ft²/sec²-°R), HII is the array of species enthalpies, h_i^* , (ft²/sec²), and HIFAC is the array of species enthalpy factors $(h_i^* - \Delta h_i^F)/T^*$, (ft²/sec²-°R), with Δh_i^F being the heat of formation.

Subroutine HCPA

The species enthalpy and specific heat profiles are returned by Subroutine HCPA. The dimensional temperature, TR, is calculated from the element of the TA array. A second-order Lagrangian interpolating polynomial is used to return the species enthalpy factor and specific heat. The enthalpy is calculated and the enthalpy and specific heat are nondimensionalized. TA, IE, HREF, CPREF, TTS and TREF are passed to Subroutine HCPA and HI and CPI are returned.

USAGE:

CALL HCPA (TA, IE, HREF, CPREF, TTS, TREF, HI, CPI) where TA is the temperature array, T^*/T_{sh} T_{ref}^* ; IE is the number of points in the TA array; HREF is the reference enthalpy, $h_{ref}^* = U_\infty^{*2}$; CPREF is the reference specific heat, $C_{p_{ref}}^* = C_{p_\infty}^*$; TTS is the shock temperature, $T_{sh} = T_{sh}^*/T_{ref}^*$; TREF is the reference temperature, $T_{ref}^* = U_\infty^{*2}/C_{p_\infty}^*$; HI is the species enthalpy, h_i^*/h_{ref}^* ; and CPI is the species specific heat, $C_{p_i}^*/C_{p_{ref}}^*$.

Subroutine INTERP

This subroutine sets up the calling argument for the two point table look up function TLU and tests the return flag from TLU.

USAGE:

CALL INTERP (XX, XN, F2, IE, FF) where XN and F2 are the arrays of coordinate points and function values, IE is the number of points in the arrays, XX is the passed coordinate value and FF is the returned function value.

Subroutine INTER3

Subroutine INTER3 uses a second-order Lagrangian interpolating polynomial interpolating on the points x_1, x_2, x_3 , with the corresponding function values f_1, f_2 and f_3 to provide a function value F corresponding to the abscissa value x.

The general form of the polynomial is

$$F(x) = \sum_{k=1}^3 f_k L_k(x)$$

where $L_k(x)$ is given by

$$L_k(x) = \prod_{\substack{m=1 \\ m \neq K}}^3 \frac{x - x_m}{x_k - x_m}$$

USAGE:

CALL INTER3 (X, X1, X2, X3, F1, F2, F3, F) where X1, X2 and X3 are the abscissa values; F1, F2, and F3 are the function values; and F is the returned function value corresponding to X.

Subroutine INTRPS

This subroutine sets up the calling argument for Subroutine SMOOTH. A principal function of the routine is to provide SMOOTH with the adjusted value of NU while preserving the value of NNU.

USAGE:

CALL INTRPS (XX, YY, X, Y, NP, NNU, DYY) where X and Y are the abscissa and ordinate arrays of NP elements, XX is the location in the X array for interpolation and differentiation, YY is the returned function value with first derivative DYY and NNU is half of the preferred number of points to be used in the log-log, walking least squares curve fit.

Subroutine INTRP3

This subroutine scans through the array X to find the location of XX and then calls INTER3 to return the function value YY.

USAGE:

CALL INTRP3 (XX, X, Y, NPNTS, YY) where X and Y are the abscissa and ordinate arrays of NPNTS elements.

Subroutine MASS

The solution of the mass conservation or continuity equation is provided by Subroutine MASS. For $s = 0$, the equations are in a reduced form and the first section of the routine is used. For $s > 0$, the general form of the equation is solved in the second section.

The shock-layer thickness, XNS, is calculated by integrating the continuity equation from 0 to y_{sh} . The expression for XNS is quadratic if the flow is axisymmetric, but is linear for two-dimensional flow. For $s > 0$ an alternate shock-layer thickness, XNSIV1 is calculated by matching the freestream mass flow into the shock with the mass flow between $y = 0$ and y_{sh} . If NAN = -1 XNS is not changed. If NAN = 1 or -2, XNS is set to XNSIV1. For NAN = 0, XNS is set to the average of itself and XNSIV1.

The normal velocity profile, VC, is then calculated by integrating the continuity equation from 0 to y . Shock coordinates are then calculated, as are values of VPG, VG, VGS, RNSH, RCSF and VS. After calculating derivatives of the v profile, control is returned to MAIN.

USAGE:

CALL MASS

Subroutine NMOMNT

The solution for the normal momentum equation is obtained in this subroutine. The trapezoidal rule is used to integrate the normal momentum equation. The derivatives of the pressure are first evaluated at the outer edge (behind the shock) and then evaluated inward. With the pressure known at the outer edge, the pressure profile can be calculated proceeding inward.

The normal momentum equation is divided into two parts for the integration. The first part is the thin viscous shock layer (TVSL) contribution. The second part is the fully viscous shock layer (FVSL) contribution. For FVSL the two contributions are added. For TVSL only the first contribution is used. The pressure profile array for the current station iteration is P2 which is averaged with P1 (from the previous station solution or iteration if $s = 0$) to give the array PC. The pressure profile used elsewhere in the program is that given by the array PC. The FVSL contribution is alternately calculated using the normal velocity profile and derivatives from the present station iteration instead of from the previous global iteration for the present value of s . The alternate pressure profile array PE is then calculated using only data from the present station iteration. This profile is printed but is not used in other program computations.

After calculating the pressure profile, the density profile is recalculated and control is returned to MAIN.

USAGE:

CALL NMOMNT

Subroutine RESET

The converged station solution data are written by this subroutine and program parameters are reset for the next station solution. Additionally, solution parameters such as drag and heat-transfer coefficients are calculated in this subroutine.

The first section of the subroutine prints the header information for the beginning of the global iteration. The skin-friction and heat-transfer coefficients are calculated and the Mach number, temperature and electron concentration profiles are calculated. Solution profiles are reset for the next station solution. The drag coefficients are calculated and the shock crossing values are reset.

The data for the converged station solution are then printed. Profiles are printed for every fifth station solution and for the values of s in the SPRF array.

USAGE:

CALL RESET

Subroutine RTEDTA

This routine reads from card input or disc storage the reaction rate data for both a binary gas mixture (dissociating oxygen) and for a seven species (six major species plus electrons) gas mixture (multicomponent air). A rate data title card is read first. For each gas mixture, the number of major species plus catalytic third bodies (NJ2 or NJ6), reaction equations (NR2 or NR6) and catalytic third bodies (NZ2 or NZ6) are read followed by the alphameric array of the species and third body names (NAME2 or NAME6). Next the reaction equations and the reaction rate constants (KREQ2 or KREQ6 and RATE2 or RATE6) are read followed by the catalytic third body array (ZSUB2 or ZSUB6). The stoichiometric coefficient arrays are later set in Subroutine SET2 by matching the species names in the KREQ array with the names in the NAME array. The first and fourth elements of the RATE arrays (CO_r and DO_r) are replaced by the $\log_e(CO_r)$ and $\log_e(DO_r)$ if the first three characters of the rate title card are 'LOG'.

USAGE:

CALL RTEDTA

Subroutine SET

The initial profiles for each global iteration are set in this routine. For a first global iteration the velocity and temperature profiles are set to straight lines, but for subsequent global iterations these profiles are set to the converged stagnation point profiles from the previous global iteration. The species profile arrays are filled with the freestream species concentration values unless the previous global iteration was for the same number of species. In that case, the species concentration profiles are set to the previous global iteration stagnation point profiles.

USAGE:

CALL SET

Subroutine SET2

The freestream and wall species concentrations are initialized in this subroutine for each global iteration. Also the stoichiometric coefficient arrays ALPHSB and BETASB are filled as is the catalytic third body efficiency array ZSUB. The routine selects the appropriate data for the arrays depending on the value of NS (2 or 6). After the arrays are set, the array data, and the reaction equations and rate constants for the global iteration are printed. The ZSUB, ALPHSB and BETSUB arrays are also printed.

USAGE:

CALL SET2

Subroutine SHVALS

The flow properties behind the shock are calculated by SHVALS. The thermodynamic and transport properties are first calculated followed by velocity, pressure, temperature and density values. The velocity components are first calculated as normal and tangent to the shock. The velocity components normal and tangent to the body are then calculated. Principal values of the shock properties returned are the average of the present and the previous station solution values. The derivatives of the shock properties are also returned.

USAGE:

CALL SHVALS (SP, CP, SPB, CPB, TTSH, VRSH, URSH, PPSH, ID)

where $SP = \sin \alpha$, $CP = \cos \alpha$, $SPB = \sin \alpha \sin \phi + \cos \alpha \cos \phi$, $CPB = \cos \alpha \sin \phi - \sin \alpha \cos \phi$, TTSH is the shock temperature, VRSH and URSH are the velocity components normal and tangent to the shock, PPSH is the shock pressure and ID is an indicator (1 or 2) for calculations in the first part of the subroutine only ($s = 0$) or for the entire subroutine.

Subroutine SMOMNT

The solution of the longitudinal momentum equation is obtained in SMOMNT. The coefficients for the equation in the standard parabolic form are first calculated followed by the shock slip variables. Subroutine SOLVE is called to return the array U2. With shock slip the shock velocity is recalculated. The average velocity profile (UC) is computed and the new profile U2 is compared with the previous station iteration velocity profile UC1. The derivative of the velocity profile is calculated and control is returned to MAIN.

USAGE:

CALL SMOMNT

Subroutine SMOOTH

SMOOTH uses a log-log, walking least squares curve fit of the form $R = AZ^B$ for interpolation and differentiation. The input array is scanned to assure the point for curve fitting is within range and that there are enough array points for the curve fit. If needed, the number of points to be used in the curve fit is reduced.

The function is curve fitted and the function and the first and second derivatives returned.

USAGE:

```
CALL SMOOTH (ZD, Z, R, NPTS, RF, RP, NU, RPP)
```

where Z and R are the coordinate and function arrays (which may contain only positive values) of dimension NPTS, ZD is the coordinate point for interpolation and differentiation, NU is half of the number of points of Z and R to be used in the curve fit and RF, RP and RPP are the returned function value and first and second derivatives with respect to Z.

Subroutine SMTHPR

This routine uses Subroutine INTRPS (and consequently SMOOTH) to interpolate for a single coordinate value. The coordinate and function values are first shifted to provide SMOOTH with only positive values and are then reshifted after the call to INTRPS.

USAGE:

```
CALL SMTHPR (S, YS, XX, YX, NPX, NNU)
```

where XX and YX are the coordinate and function arrays of dimension NPX to be used in the curve fitting by SMOOTH, S is the coordinate value, YS is the returned function value and two NNU points are to be used in the curve fit procedure.

Subroutine SOLVE

This subroutine calculates the solution of parabolic partial differential equations in the standard form. Required for the solution are the upstream function values (W1), the coefficients of the parabolic partial differential equation in standard form (A1, A2, A3, and A4), the finite-difference grid interval array (DN) and the constants E1 and F1 which set the wall value or gradient. The equation is solved by equivalently using a tridiagonal finite-difference matrix. The matrix coefficients are evaluated from the wall outward and then the function is evaluated from the outer edge (shock) inward. With shock slip, the function shock value is calculated using the slip variables CS1 and CS2.

USAGE:

CALL SOLVE (W1, W2, E1, F1, CRNI, W2IE, CS1, CS2, SSFAC)

where W1 is the previous station solution of the equation, W2 is the returned solution, E1 and F1 are constants for the wall value of W2 (E1 = 0 gives $W2 = F1$ at the wall and E1 = 1 with F1 = 0 gives the gradient of W2 at the wall equals zero), CRNI (= 1) specifies a fully implicit finite-difference procedure, W2IE is the shock value of W2, CS1 and CS2 are the slip variables and SSFAC denotes shock slip (1.0) or no shock slip (-1.0).

Subroutine SPECIE

The solution for the species conservation equation is obtained in this routine. The Q1 and Q2 arrays are used as substitute arrays to obtain the derivatives of the species flux terms, then used in the calls to SOLVE for the species concentrations and finally in computing the derivatives of the species concentration profiles. Direct solutions are obtained for NS - 1 species equations and the profile for the last species, O₂ for dissociating oxygen and N₂ for multicomponent air, is obtained by summing over the other species.

The coefficients of the standard form of the species conservation equations are calculated, the slip variables CS1 and CS2 are calculated, the wall value constants E1 and F1 are set and Subroutine SOLVE is called to return the new species concentration profiles.

The species profiles are checked for being within a 0.0 - 1.0 range and the profiles and production terms for the NSth species are recalculated. Finally, the sums are obtained for the enthalpy-production term product, the enthalpy-production term derivative product, the specific heat-species flux term product and the enthalpy-species flux to the wall product. Control is then returned to MAIN.

USAGE:

CALL SPECIE

Subroutine THERM

The species production terms and transport properties are calculated in this subroutine. To reduce the computing time required for the dissociating oxygen chemistry model, the properties are calculated in line using expressions specific for a two component gas mixture instead of the more general expressions used in the production term and transport property subroutines for a multicomponent gas mixture.

The first part of the subroutine is accessed only once at the beginning of each global iteration. This part calculates the freestream and reference variables. Also, the species viscosity curve fit constants and reaction rate constants for dissociating oxygen are set in this part of the subroutine.

The second part of the routine is accessed for each station iteration. The enthalpy and specific heat profiles are returned by HCPA and, for a multicomponent gas mixture, the viscosity and thermal conductivity arrays are returned by VISCNA.

The next section computes the production terms for the binary gas (dissociating oxygen) chemistry and also the equilibrium atom concentration (CAEQ) for the binary gas. For the multicomponent gas, the production terms are returned by Subroutine WISUB. The next section optionally computes the viscosity and thermal conductivity for the binary gas. The species flux terms are then calculated. The AJM array is set to zero since multicomponent diffusion is not included. The arrays of $\bar{\mu}'/\bar{\mu}$ and \bar{k}'/\bar{k} are then formed where the primes indicate differentiation with respect to y and the bars denote μ/μ_{sh} and k/k_{sh} .

In the final section of the routine the wall equilibrium concentration for dissociating oxygen is calculated as is the equilibrium wall enthalpy for dissociating oxygen, $h_{w,eq}$, HTFLB. For the multicomponent gas, HTFLB is replaced by h_w . Program control then is returned to MAIN.

USAGE:

CALL THERM (ISKI, BRAD, CONO, VISCO, EPS, VIS2)

where ISKI is a control variable indicating the first or second part of the routine to be used, BRAD is the nose radius in feet, CONO and VISCO are the edge or shock thermal conductivity and viscosity, EPS is the Reynolds number parameter, ϵ , and VIS2 is the wall viscosity.

Function TLU

Linear, two point interpolation is used to return the value from the Z array associated with the name TLU for the XSTAR value in the X array. The array dimensions are NTABLE. NFLAG is a function return code, 0 if XSTAR is within the range of the X array, 1 (with TLU = 0.0) if XSTAR is not in the range of the X array. The X array must be strictly increasing.

USAGE:

TLU (NTABLE, Z, X, XSTAR, NFLAG)

Subroutine VISCNA

This routine computes the viscosity and thermal conductivity arrays for all points of the temperature array, TC.

USAGE:

CALL VISCNA (TC, CC, CPI, IE, VST, CST, TTS, TREF, CPREF)

where TC is the input temperature array, CC is the species concentration array, CPI is the specific heat array, IE is the number of points in the arrays, VST and CST are the mixture viscosity and thermal conductivity arrays, TTS is the shock temperature and TREF and CPREF are the reference temperature and specific heat.

Subroutine VISCON

The viscosity and thermal conductivity for a single temperature value are calculated by this subroutine.

USAGE:

CALL VISCON (CI, CPI, AMU, AKAY, TR)

where TR is the temperature in degrees Rankine, CI and CPI are the species concentrations and specific heats and AMU and AKAY are the mixture viscosity and thermal conductivity.

Subroutine VPRFLE

The normal velocity profile from the previous global iteration (written on tape or disc) is retrieved and smoothed in this routine for a fully viscous shock layer. A minimum of eight records are needed from the previous global iteration. The gradient of the normal component of the shock velocity is returned by Subroutine INTERP and the normal velocity profile values are returned by Subroutine SMTHPR.

USAGE:

CALL VPRFLE (S, VP, V, IE, NTR, ICALL)

where S is the surface distance location, VP is the derivative with respect to S of the component of the shock velocity normal to the body, V is the normal velocity profile array of dimension IE, NTR is the logical unit number for the tape or disc and ICALL is a control variable (= 1, the first eight records are read; $\neq 1$, further records are read, if available and as needed, to have S in the proper span of the records).

Subroutine WISUB

Subroutine WISUB computes the species production terms for the gas mixture. The forward and backward reaction rates are computed. The two parts of the production rate terms are computed followed by the derivative of the production term with respect to temperature in degrees Kelvin.

USAGE:

CALL WISUB (RHON, T, N)

where RHON is the density in slugs/ft³, T is the temperature in degrees Rankine and N is the array subscript for the CC, W0, W1 and DW arrays.

Subroutine BLOCK DATA

Tables of thermodynamic data and other constants are initialized in BLOCK DATA. The species specific heats in ft²/sec² - °R are in CPTAP, the species enthalpy, as $(h_i - \Delta h_i^F)/T$, in ft²/sec² - °R are in HTAB, the corresponding temperature values are in TMPTAB and NTAB is the number of table entries.

The species viscosity curve fit constants are in VSA, VSB and VSC, the species heats of formation are in DELHIF, the molecular weights in EMI and the species names in NSPI in the order for which the species data are assigned. Note that O and O₂, the species for dissociating oxygen, are the first two species in the NSPI array. Thus, a calculation for dissociating oxygen uses the thermodynamic properties and other data for the first two species only.

DESCRIPTION OF VARIABLES IN COMMON

The Fortran variables which occur in the labeled common are listed below with the name of the common block in which they occur along with a brief description of the variables.

Fortran Symbol	Common Name	Description
AA(51)	COMAR1	array used to integrate ρu .
AJB(51,6)	COMDBL	factor in transport term for species equation, kLe/C_p .
AJM(51,6)	COMDBL	multicomponent Lewis number factor in species equation, set equal to zero.
ALP	COMXR	shock angle, α .
ALPHSB(15,11)	COMABZ	α_{rj} , forward stoichiometric coefficients.
ALSUB(15)	COMABZ	$\sum_r \alpha_{rj} - 1$
ALT	COMXR	altitude in feet.
A1(51)	SOLV	coefficients of the standard form of the conservation equations.
A2(51)		
A3(51)		
A4(51)		
BB(51)	COMAR1	array used to integrate $\eta \rho u$.
BETASB(15,11)	COMABZ	β_{rj} , backward stoichiometric coefficients.
BETSUB(15)	COMABZ	$\sum_r \beta_{rj} - 1$
BO	COMXR	T_w^*/T_o^*
CAEQ(51)	COMAR1	Equilibrium species concentration of atomic oxygen that would exist for dissociating oxygen at the local temperature and pressure.
CAINF	COMBC	C_{a_∞} , freestream atomic oxygen concentration.
CAT	COMG	indicator for fully catalytic (1.0) or noncatalytic wall (-1.0) boundary condition.

CAW	COMBC	C_{a_w} , input atom concentration at surface for dissociating oxygen.
CC(51,6)	COMDBL	C_{ij} , species concentrations.
CCFAC	COMFAC	weighting function for updating the C1 array at the stagnation point.
CCL(51,6)	COMDBL	array of previous iteration values of the array CC. CCL is used in the convergence test.
CCN(51,6)	COMDBL	derivative of C_{ij} with respect to η .
CDF	COMXR	coefficient for friction drag.
CDFD	COMXR	term in calculating CDF.
CDF1	COMXR	term in calculating CDFD.
CDF2	COMXR	term in calculating CDFD.
CDP	COMXR	coefficient for pressure drag.
CDPD	COMXR	term in calculating CDP.
CDP1	COMXR	term in calculating CDPD.
CDP2	COMXR	term in calculating CDPD.
CIE(6)	COMEDG	$C_{i_{sh}}$, species concentrations behind the shock as calculated by the program.
CINF(6)	COMFSA	C_{i_∞} , freestream species concentrations.
CINF6(6)	COMBC	the input freestream species concentrations for multicomponent air.
CIW(6)	COMW	C_{i_w} , the wall species concentrations as calculated by the program.
CIWW(6)	COMW	C_{i_w} , the wall species concentrations for a fully catalytic surface.
CIWW6(6)	COMBC	the input wall species concentrations for multicomponent air for a fully catalytic surface.
CK	COMG2	the value of κ at s .
CK2	COMG2	the value of κ at $s + ds/2$.

CNS	COMG	y_{sh} , shock-layer thickness, more exactly, the average of y_{sh} at the present station and at the previous station.
CON(51)	COMAR1	$\bar{\mu}$, μ/μ_{sh} , viscosity.
CONO	INSH	μ_{sh}/Pr
CONREF	COMREF	$\mu_{ref}^* C_{pref}^*$, reference thermal conductivity.
C01	COMAR1	array used in calculating the derivative of v with respect to s .
C02	COMAR1	a second array used in calculating the derivative of v with respect to s .
CP	COMG1	$\cos \alpha$ at $s + ds/2$.
CPB	COMG1	$\cos \alpha \sin \phi - \sin \alpha \cos \phi$ at $s + ds/2$.
CPI(51,6)	COMDBL	C_{pi}^* , $ft^2/sec^2 - ^\circ R$, species specific heat.
CPIFS(6)	COMFSA	C_{pi}^* , $ft^2/sec^2 - ^\circ R$, freestream species specific heat.
CPIW(6)	COMW	C_{piw}^* , $ft^2/sec^2 - ^\circ R$, species specific heat at the surface.
CPJSUM(51)	COMSUM	$\sum_i C_{pij} J_{ij}$, sum over the species of the product of specific heat and the diffusional flux.
CPREF	COMREF	$C_{p\infty}^*$, the reference specific heat.
CPST(51)	COMAR1	$\sum_j C_{pij} C_{ij}$
CPTAB(50,6)	COMTAB	table of species specific heat vs. temperature from BLOCK DATA.
CRNI	COMG	indicator (set to 1.0 and never changed) specifying a fully implicit finite-difference solution procedure.
CR0(15)	RTECON	Coefficients for the forward reaction rate equations.
CR1(15)		
CR2(15)		
CSF	COMG3	$\cos \phi$ at s .

CSF2	COMG2	$\cos \phi$ at $s + ds/2$.
C1(51,6)	COMDBL	array of species concentrations from the previous station iteration (if $s = 0$) or from the previous station (if $s > 0$).
C2(51,6)	COMDBL	array of species concentrations for present station iteration.
C20(51,6)	COMDBL	array of species concentrations at $s = 0$, saved for starting subsequent global iteration.
DELHIF(6)	COMFSA	standard species heat of formation at 0°K .
DIF	COMTST	maximum difference in the u/u_{sh} arrays between station iterations.
DIFI(8)	COMTST	maximum difference in the u/u_{sh} , T/T_{sh} , and C_{ij} arrays between station iterations.
DN(51)	SOLV	Δn , or $\Delta y/y_{sh}$, normal spacing in the finite difference grid.
DR0(15)	RTECON	Coefficients for the backwards reaction rate equations.
DR1(15)		
DR2(15)		
DS	SOLV	Δs , or ds , step size in the streamwise direction.
DW(51,6)	COMDBL	derivative of the species production term with respect to temperature ($^\circ \text{K}$).
ELN(6)	COMEL	number of nitrogen atoms per species molecule.
ELO(6)	COMEL	number of oxygen atoms per species molecule.
EMBAR(51)	COMART	\bar{M} , mixture molecular weight.
EMI(6)	COMVS	M_i , species molecular weight.
EPS	INSH	ϵ , Reynolds number parameter, $\epsilon = (\mu_{ref}^*/\rho_\infty^* U_\infty^* R_n^*)^{1/2}$
GAMMMI(15,6)	COMABZ	$-(\beta_{rj} - \alpha_{rj})$ if $(\beta_{rj} - \alpha_{rj}) < 0$
GAMMPL(15,6)	COMABZ	$(\beta_{rj} - \alpha_{rj})$ if $(\beta_{rj} - \alpha_{rj}) > 0$
HANGLE	BODY	asymptotic half angle for hyperboloids.
HDWSUM(51)	COMSUM	sum over the species of the product of DW and HI.

HI(51,6)	COMDBL	h_i^* , ft ² /sec ² , species static enthalpy.
HINF(6)	COMFSA	$h_{i_\infty}^*$, ft ² /sec ² , freestream species static enthalpy.
HIW(6)	COMW	$h_{i_w}^*$, species static enthalpy at the body surface.
HJSUMW	COMSUM	sum over the species of the product of enthalpy and the diffusional flux at the wall.
HREF	COMREF	$h_{ref}^* = U_\infty^{*2}$, reference enthalpy.
HTAB(50,6)	COMTAB	$(h_i^* - \Delta h_i^F)/T$, ft ² /sec ² - °R, table of species static enthalpy over temperature versus temperature from BLOCK DATA.
HTFLB	COMW	mixture enthalpy at the wall if NS = 6; if NS = 2, the wall enthalpy for O-O ₂ in equilibrium.
HWSUM(51)	COMSUM	sum over the species of the product of enthalpy, species concentration and species production terms.
I	COMG	index for the streamwise solution DO loop.
IE	SOLV	number of points in the normal direction of the finite-direction grid.
IEND	COMXR	maximum number of stations in the streamwise direction; upper limit of the variable I.
IGEOM	BODY	indicator for body geometry, 1. hyperboloid 2. paraboloid 3. geometry defined by table of r, z and s
IJK	KJI	indicator, 0 for first call to Subroutine GEOM, 123 for subsequent calls.
IM	SOLV	IE-1.
IUN	COMXR	input unit number for reaction rate data.
JFAC	BODY	indicator for axisymmetric flow (1) or two-dimensional flow (0).
K	COMG	index for the global iteration DO loop.
KNTR1	KNTR	counter for the number of records read on unit NTR.

KNTW1	}	KNTR	counters for the number of records written on unit NTW.
KNTW2			
KPLTTP		COMXR	indicator for plot data being written on unit NTPL; 0, no; 1, yes.
KREQ2(15,6)	}	COMSET	arrays for the reaction equations for the dissociating oxygen (KREQ2) and multicomponent air (KREQ6); used to set the values of ALPHSB and BETASB.
KREQ6(15,6)			
KRTITL(18)		COMSET	title card for reaction rate data. If 'LOG' appears in the first three spaces, CO(J) and (DO)J are replaced by ALOG(CO(J)) and ALOG(DO(J)).
KTITLE(20)		TITLE	title card for the computation case being run. KTITLE is printed with each station solution.
NAME2(11)	}	COMSET	arrays of species and catalytic third body names, left justified.
NAME6(11)			
NAN		INV2	indicator for analytic or nearly analytic bodies; 1, yes; 0, no. Negative values of NAN specify alternate methods of calculating the shock-layer thickness, XNS. (See the description of Subroutine MASS).
NITER		COMG	counter for the number of iterations at each streamwise station.
NITMIN		COMXR	control variable allowing DS to be doubled if $NITER \leq NITMIN$.
NITTOT		COMXR	total number of station iterations performed for each global iteration.
NJ		COMNS2	number of species plus catalytic third bodies.
NJ2	}	COMSET	values to be assigned to NJ for dissociating oxygen (NJ2) or multicomponent air (NJ6).
NJ6			
NR		COMNS2	number of reaction equations.
NR2	}	COMSET	values to be assigned to NR for dissociating oxygen (NR2) or multicomponent air (NR6).
NR6			

NS	COMNS	number of major chemical species; 2 for dissociating oxygen, 6 for multicomponent air.
NSM1	COMNS2	NS - 1.
NSOLD	COMSO	value of NS for the previous global iteration.
NSPI(6)	COMVS	alphameric array of the six major chemical species, left justified, from BLOCK DATA.
NSPRF	COMPRF	number of values of s at which solutions are to be specifically obtained and with profiles printed; maximum value, 10.
NTAB	COMTAB	number of entries in the CPTAB, HTAB and TMPTAB arrays, 49.
NTOT	COMXR	total number of station iterations for all global iterations.
NTPL	COMXR	output unit number for optional plot data, (13).
NTW	COMXR	unit number for storing v profiles for subsequent global iteration, 15 or 16. Profiles are written on unit NTW and read from unit NTR. The values are switched at the end of each global iteration.
NZ	COMNS2	NJ - NS, number of catalytic third bodies.
NZ2	COMSET	NJ2 - NS2.
NZ6	COMSET	NJ6 - NS6.
OLDSLP	COMXR	previous value of XNSP(I).
PC(51)	COMAR1	P/P_{sh} , average of the P1 and P2 arrays.
PCN(51)	COMAR1	derivative of PC with respect of η .
PE(51)	COMAR1	alternate pressure array.
PFAC(51)	COMAR1	pressure related factor occurring in the standard form of the energy and s momentum equations.
PHI	COMXR	body angle at $s + ds/2$.
PINF	COMFS	P_{∞}^* , $1\text{bf}/\text{ft}^2$, freestream static pressure.
PPS	OUTSH	average of current and previous station or iteration values of P_{sh} .

PPSO	COMSO	P_{sh} at the stagnation point.
PPS1	OUTSH	P_{sh} for the previous station or, if $s = 0$, iteration.
PPS2	OUTSH	P_{sh} for the present station iteration.
PREF	COMREF	P_{ref}^* , reference pressure, $\rho_{\infty}^* U_{\infty}^{*2}$.
P2(51)	COMAR1	derivative of P/P_{sh} with respect to s .
PSP	OUTSH	derivative of P_{sh} with respect to s .
P0(51)	COMAR1	array of P/P_{sh} at the stagnation point.
PON(51)	COMAR1	derivative of P0 with respect to η .
P1(51)	COMAR1	array of P/P_{sh} for the previous station, or, if $s = 0$, iteration.
P1N(51)	COMAR1	derivative of P1 with respect to η .
P2(51)	COMAR1	array of P/P_{sh} for the present station iteration.
P2N(51)	COMAR1	derivative of P2 with respect to η .
Q1(51)	COMAR1	substitute arrays, principally for solving the species conservation equations.
Q2(51)		
R	COMVS	universal gas constant, from block data, 49686 lb ft ² /(lb-mole sec ² °R).
RATE2(15,6)	COMSET	reaction rate constants, C0, C1, C2, D0, D1, D2 for the dissociating oxygen (RATE2) or for multicomponent air (RATE6).
RATE6(15,6)		
RC(51)	COMAR1	ρ/ρ_{sh} , density, average of R1 and R2.
RCON(51)	COMAR1	$(1/\bar{k}) (d\bar{k}/d\eta)$ where $\bar{k} = k/k_{sh}$.
RCSF(51)	COMAR1	$y_{sh} \cos \phi / (r_w + y_{sh} \eta \cos \phi)$.
REFAC	COMG	$\rho_{sh} v_{sh} y_{sh} / \epsilon^2 u_{sh}$.
REYIN	COMFS	$Re_{\infty}, \rho_{\infty}^* U_{\infty}^* R_n^* / u_{\infty}^*$, freestream Reynolds number.
REYSH	OUTSH	$Re_{sh}, \rho_{\infty}^* U_{\infty}^* R_n^* / u_{sh}^*$, shock Reynolds number.
RINF	COMFS	ρ^* , freestream density, slugs/ft ³ .

RNSH(51)	COMAR1	$y_{sh}/(1 + \kappa y_{sh} \eta)$.
RREF	COMREF	$\rho_{ref}^* = \rho_{\infty}^*$.
RRS	OUTSH	average of current and previous station or iteration values of ρ_{sh} .
RRS1	OUTSH	ρ_{sh} for the previous station or, if $s = 0$, the previous station iteration.
RRS2	OUTSH	ρ_{sh} for the present station iteration.
RS	COMG3	r_w , body radius at s .
RSH	COMRX	r_{sh} , radial coordinate of current shock point.
RSP	OUTSH	derivative of ρ_{sh} with respect to s .
RS2	COMG2	r_w , body radius at $s + ds/2$.
RVISC(51)	COMAR1	$1/\bar{\mu} (d\bar{\mu}/d\eta)$ where $\bar{\mu} = \mu/\mu_{sh}$.
R1(51)	COMAR1	ρ/ρ_{sh} , density at previous station, or, if $s = 0$, from the previous station iteration.
R2(51)	COMAR1	ρ/ρ_{sh} , density for the current station iteration.
S	INSH	$s = s^*/R_n^*$, surface distance coordinate.
SEND	COMXR	final value of s .
SIF	COMG3	$\sin \phi$ at s .
SIGM	PRLE	σ , Prandtl number.
SMALLT	COMSML	a small number for test purposes.
SP	COMG1	$\sin \alpha$ at $s + ds/2$.
SPB	COMG1	$\sin \alpha \sin \phi + \cos \alpha \cos \phi$ at $s + ds/2$.
SPRF(10)	COMPRF	array of values of s at which specific solutions are to be obtained and profiles printed.
SSFAC	COMG	indicator for shock slip; 1.0, yes; -1.0, no.
SWFAC	COMG	dummy indicator for wall slip; 1.0, yes; -1.0, no. The program only includes no wall slip.
TB	COMW	T_w^* , wall temperature, $^{\circ}R$.

TC(51)	COMAR1	T/T_{sh} , temperature, average of T1 and T2.
TCIE	COMEDG	TC(IE).
TCNW	COMBC	derivative of T/T_{sh} with respect to η at the wall.
TCW	COMW	TC(1).
THIN	COMG	indicator for TVSL (1.0) or FVSL (-1.0) flow.
TINF	COMFS	T_{∞}^* , freestream temperature, $^{\circ}R$.
TMPTAB(50)	COMTAB	T_{∞}^* , $^{\circ}R$, table of temperature values for species enthalpy and specific heat, from BLOCK DATA.
TPSH	INSH	$d\bar{T}/d\eta$ at the shock where $\bar{T} = T/T_{sh}$.
TREF	COMREF	T_{ref}^* , reference temperature, $^{\circ}R$, $U_{\infty}^{*2}/C_{p\infty}^*$.
TSP	OUTSH	derivative of T_{sh} with respect to s .
TTS	OUTSH	T_{sh} , shock temperature, average of TTS1 and TTS2.
TTS0	COMSO	T_{sh} at the stagnation point.
TTS1	OUTSH	T_{sh} at the previous station or, if $s = 0$, for the previous station iteration.
TTS2	OUTSH	T_{sh} for the present station iteration.
TW	COMW	T_w , wall temperature.
T1(51)	COMAR1	T/T_{sh} for the previous station, or, if $s = 0$, for T_{sh} the previous station iteration.
T2(51)	COMAR1	T/T_{sh} for the present station iteration.
T20(51)	COMAR1	T/T_{sh} at the stagnation point.
T21(51)	COMAR1	T/T_{sh} from the previous station iteration.
UC(51)	COMAR1	u/u_{sh} , tangential velocity, average of U1 and U2.
UCN(51)	COMAR1	derivative of UC with respect to η .
UC1(51)	COMAR1	u/u_{sh} from the previous station iteration.

UFAC	COMFAC	factor to average the updating of the U1 and T1 profiles at the stagnation point if more than 20 iterations are required.
UINF	COMFS	U_{∞}^* , freestream velocity, ft.
UPSH	INSH	derivative of the component of u/u_{sh} tangent to the shock with respect to η .
URSH	COMUV	u_{sh} , shock velocity component tangent to the shock.
UREF	COMREF	U_{ref}^* , reference velocity, U_{∞}^* .
USP	OUTSH	derivative of u_{sh} with respect to s .
UUS	OUTSH	u_{sh} , shock velocity component tangent to the body, average of UUS1 and UUS2.
UUS0	COMSO	u_{sh} , at the stagnation point.
UUS1	OUTSH	u_{sh} at the previous station, or, if $s = 0$, from the previous station iteration.
UUS2	OUTSH	u_{sh} for the present station iteration.
U1(51)	COMAR1	u/u_{sh} at the previous station or, if $s = 0$, from the previous station iteration.
U2(51)	COMAR1	u/u_{sh} for the present station iteration.
U20(51)	COMAR1	u/u_{sh} , at the stagnation point.
VC(51)	COMAR1	v/v_{sh} , normal velocity component.
VCD(51)	COMAR1	$v = v^*/u_{ref}^*$; $VC \times VVS$.
VCI1(51)	COMAR1	v profile from the previous global iteration at s .
VCI2(51)	COMAR1	v profile from the previous global iteration at $s + ds/2$.
VG(51)	COMAR1	average of VCI1 and VCI2.
VGN(51)	COMAR1	derivative of VG with respect to η .
VGS(51)	COMAR1	derivative of VG with respect to s .
VISC(51)	COMAR1	μ/μ_{sh} , viscosity.
VISCO	INSH	μ_{sh}^*/μ_{ref}^* .

VPG	COMG	average of VSP at s and at $s + ds/2$ from the previous global iteration.
VRSH	COMUV	v_{sh} , shock velocity component normal to the shock.
VS(51)	COMAR1	derivative of the v profile with respect to s .
VSA(6)	COMVS	coefficients for the species viscosity curve fit equations.
VSB(6)		
VSC(6)		
VSP	OUTSH	derivative of v_{sh} with respect to s .
VSPP1	COMVSP	derivative of v_{sh} with respect to s at s , from the previous global iteration.
VSPP2	COMVSP	derivative of v_{sh} with respect to s at $s + ds/2$, from the previous global iteration.
VSREF	COMREF	μ_{ref}^* , reference viscosity, lbf-sec/ $^{\circ}$ R, corresponding to T_{ref}^* .
VVS	OUTSH	v_{sh} , shock velocity component normal to the body, average of VVS1 and VVS2.
VVS0	COMS0	v_{sh} , at the stagnation point.
VVS1	OUTSH	v_{sh} at the previous station or, if $s = 0$, from the previous station iteration.
VVS2	OUTSH	v_{sh} for the present station iteration.
V0(51)	COMAR1	v/v_{sh} , at the stagnation point.
VON(51)	COMAR1	derivative of V0 with respect to η .
V1(51)	COMAR1	v/v_{sh} profile at the previous station, or, if $s = 0$, from the previous station iteration.
V2(51)	COMAR1	v/v_{sh} profile for the present station iteration, equal to VC.
V2N(51)	COMAR1	derivative of V2 with respect to η .
WREF	COMREF	W_{ref}^* , reference value for nondimensionalizing the production terms, U_{∞}^*/R_n^* .
WVFAC	COMXR	averaging factor for the v/v_{sh} profiles before they are written on disc.

W0(51,6)	COMDBL	first component of the species production term.
W1(51,6)	COMDBL	second component of the species production term.
XB	COMG3	x, axial coordinate of the current solution point.
XJFAC	BODY	indicator for axisymmetric (1) or two-dimensional (0) flow, the real variable equivalent of JFAC.
XLE	PRLE	Le, binary Lewis number.
XN(52)	SOLV	array of n , y/y_{sh} , values.
XNS	INSH	y_{sh} , shock layer thickness calculated for the current station.
XNSIVO	INV2	term in computing y_{sh} .
XNSIVI	INV2	y_{sh} as calculated by matching the freestream mass flow through the shock with the mass flow through the shock layer.
XNSP(202)	COMARL	derivative of XNS with respect to s at s .
XNSPM	COMG2	derivative of XNS with respect to s at $s + ds/2$ from the previous global iteration.
XNSTMP	INV2	storage variable for the value of y_{sh} obtained by integrating the n momentum equation.
XNSO	COMXR	an initial value for y_{sh} at the stagnation point.
XNSI	COMG3	value of y_{sh} at the previous station, or, if $s = 0$, from the previous station iteration.
XSH	COMXR	X_{sh} , axial coordinate of the current shock point.
XSOL(200)	COMARL	array of s values at which solutions were obtained.
XU25	COMTST	U2(15), the fifteenth value of the U2 array.
ZSUB(5,6)	COMABZ	array of the third body occurrences or the third body catalytic efficiencies relative to Argon.
ZSUB2(5,6)	COMSET	values to be given ZSUB for dissociating oxygen (ZSUB2) or for multicomponent air (ZSUB6).
ZSUB6(5,6)		

DESCRIPTION OF INPUT DATA

To reduce the need to read in a large number of data cards for each case, most of the card input can be read on input units other than the main card input unit. The auxiliary input unit numbers are initialized but can be changed, in most cases, through the namelist input data. The input data are described in the order that it is required with the unit number and format.

Data Input in MAIN

KTITLE, Unit 5, (20A4)

An alphameric card image array of descriptive information for the particular case being run. KTITLE is printed as a header for each streamwise solution.

INPUT, Unit 5 (NAMELIST format)

The principal control and scalar variables are read through the NAMELIST INPUT. Many of the variables are initialized before INPUT is read so that only the principal variables need to be included in the NAMELIST. The individual variables for INPUT are described in a separate subsection below.

(CINF6(J), J=1,6), Unit 5, (6F10.5)

Freestream species concentrations for the six principal air species, O, O₂, NO, N, NO⁺ and N₂.

(CIWW6(J), J=1,6), Unit 5, (6F10.5)

Species concentration for the six principal air species at the body surface. These values are not used for an NCW (CAT=-1.0) case, but are used for an ECW (CAT=1.0) case. For ECW, the values for CIWW6 correspond to the equilibrium wall concentrations.

SN(N), SHSLPN(N), ENSHN(N), ENO, Unit NTSH (default value for NTSH is 5), (3E15.6, A1), optional, read if NDATA \neq 0.

Array members (up to 300) defining an initial shock shape.

SN, s, location on the body surface of the corresponding shock points.

SHSLPN, local slope of the shock, i.e., dy_{sh}/ds .

ENSHN, y_{sh} , local shock-layer thickness.

Note: SHSLPN is recalculated from differentiating ENSHN and averaging four times this derivative over three points. The user might wish to use the value of SHSLPN which is read in and eliminate the need for the ENSHN array retaining the smoothing procedure.

ENO, a control character indicating if more cards are to be read. If ENO is a blank character, more cards are read. If ENO is any non-blank character, no more cards of these arrays are read and NSDATA is set to the current value of N.

STWA(N), TWA(N), ENO, Unit NTTWA (default value for NTTWA is 5), (2E15.6,A1); optional, read if KTWAL \neq 0.

Array members (up to 100) defining a body surface temperature distribution.

STWA, s, surface location for the corresponding temperature.

TWA, surface temperature, °R.

ENO, control character as described above. If ENO is non-blank no more cards for these arrays are read and NPTT is set to the current value of N.

SPRF, Unit 5, (10F8.0); optional, read if NSPRF \neq 0.

An array (maximum 10) of values of s, the number being equal to NSPRF, at which specific solutions are to be obtained and full profiles are to be printed. The values of this array should be selected to avoid abrupt and large changes in DS, if possible. If a solution is desired at a specific location, two or three solution stations upstream should be specified so that the program approaches the desired solution station with a constant DS.

SPRF(NSPRF) is set equal to SEND.

Data Input in Subroutine RTEDTA

Subroutine RTEDTA is called once by MAIN for each case to read the reaction rate data. All data in this subroutine are read on input unit IUN (default value for IUN is 19). The value of IUN is passed through common from MAIN.

KRTITL, (A3,17A4)

An alphameric array giving header information for the reaction rate data.

The remaining data are read for both a two and a seven species chemistry system. Each variable ends with the character 2 or 6 (e.g. NJ2 and NJ6, being the values of NJ for a two or a seven species chemistry system. The values for the required system are later selected in subroutine SET2.

NJ2, NR2, NZ2, (3I3)

The values of NJ, NR and NZ for the two species chemistry system.

(NAME2(I), I=1,NJ), 20A4

Species and catalytic third body names, left justified in the A fields.

((KREQ2(I,J), J=1,6), (RATE2,(I,K),K=1,6), I=1,NR2), (6(1X,A4),2(F10.0,
F6.0,F4.0))

KREQ2, the specie names for the reaction equation. The first three are for the forward reaction, the second three are for the backward reaction. Blanks are to be included as needed. As an example of the equation:

$O2.. + O2.. + = O... + O... + O2..$ where the periods represent blank characters.

RATE2, the forward and backward rate constants; C0, C1, C2, D0, D1, D2; for the corresponding reaction equations. C0 and D0 may be in either of the two conventional forms (e.g. for the equation above C0 as 44.92469 or 3.24×10^{19}). Internally the program uses the first form. If the second form is input, the form is indicated to the program by the first three characters of KRTITL being 'LOG'. If so, C0 and D0 are replaced by $\log_e(C0)$ and $\log_e(D0)$.

((ZSUB2(I,J),J=1,NS2),I=1,NZ2),(6F10.5), optional, read if NZ2 (=NJ2-NS2)>0.

The ZSUB array for the two species chemistry system. The corresponding variables are also read for the seven species chemistry system, these being NJ6, NR6, NZ6, NAME6, KREQ6, RATE6, and ZSUB6.

Data Input in Subroutine GEOM

If the body geometry is specified in tabular form (IGEOM=3), the first time subroutine GEOM is called by MAIN the body geometry tables are read.

ZAX(I), RWA(I), SUR(I), CKA(I), THA(I), KND, Unit IRN4 (assigned value for IRN4 is 4), (5E14.6,A1)

Arrays, of up to 300 members, specifying the body geometry.

ZAX, $z = z^*/R_n^*$, axial coordinate of the current point.

RWA, $r = r^*/R_n^*$, the radial distance from the body axis to the surface for the current point.

SUR, $s = s^*/R_n^*$, the surface distance from the stagnation point to the current point.

CKA, $\kappa = \kappa^*/R_n^*$, surface curvature.

THA, θ , angle between body tangent and axis.

KND, control character. If KND is a blank character, more cards are read for the geometry arrays. If KND is a non-blank character, no more cards are read and I is retained as the number of elements in the arrays.

Input Data in NAMELIST INPUT

The variables below are read through NAMELIST INPUT on Unit 5. On some computing systems (e.g. IBM) variables in the NAMELIST statement need not appear in the card input and many of the variables are initialized before the READ (5,INPUT) statement and need not appear in the card stream. The real variables are described first followed by the integer variables. The initialized value, when appropriate, is given in parentheses after the variable name.

ALT, variable to indicate in the output the altitude of the case conditions. ALT is not actually used in the calculations.

BRAD, R_n^* , the body nose radius in feet.

CAINF, (0.0), the freestream atom concentration for a binary reacting mixture.

CAT, (1.0), indicator for catalytic or noncatalytic wall condition; 1.0 for catalytic wall; -1.0 for noncatalytic wall.

CAW, (0.0), the atom concentration for a binary reacting mixture at the wall for a catalytic wall. CAW is not used for a noncatalytic wall.

CCFAC, (0.0), weighting factor used in the updating of the species concentration profiles for a seven species gas mixture at the stagnation point.

CONVRG, (0.01), convergence criterion. The variable values for U, T and C_i (except for NO^+) are required to change by less than CONVRG between station iterations at each point in the finite-difference grid for convergence. For NO^+ the convergence criterion is $100 \times \text{CONVRG}$.

DS, (0.1), initial step size in the s direction. After the stagnation point solution, DS may be doubled or halved depending upon the values of DSMAX, NITMIN and NITMAX.

DSMAX, (5.0), an approximate upper limit of the step size, DS. DS may be doubled until $\text{DS} > \text{DSMAX}$ but then DS may not be further increased.

HANGLE, (10.0), asymptotic half angle for hyperboloids.

PRINTCI, (0.0), control variable which allows printing of full profiles for each station iteration with atomic balance sums if PRINTCI=1.0. Printing of these profiles is suppressed if PRINTCI=0.0.

RINF, ρ_∞^* , freestream density in slugs/ft³.

SEND, (0.0), the final value at which a solution is to be obtained. If NDATA=0, SEND is set to $\text{DS} \times (\text{IEND}-1)$. If NDATA $\neq 0$, SEND is reset to SN(NSDATA) if $\text{SEND} = 0.0$ or $> \text{SN(NSDATA)}$.

SIGM, (0.7), σ , Prandtl number.

SITEST, (0.0001), convergence criterion for the shock temperature returned by Subroutine SHVALS.

SMALLT, (1.0×10^{-6}), small factor to be added to or subtracted from 1.0. For computations with 14 or more significant figure accuracy (equivalent to IBM double precision) SMALLT should be set to 1.0×10^{-10} .

SSFAC, (-1.0), control variable which specifies if the calculation is to be with no shock slip (-1.0) or with shock slip (1.0).

SWFAC, (-1.0), control variable, unused except for header output, specifies no wall slip.

TB, T_w^* , body surface temperature, °R.

THINI, (-1.0), control variable for the second and subsequent global iterations being TVSL (1.0) or FVSL (-1.0). THIN is set equal to THINI at the end of each global iteration.

TINF, T_∞^* , freestream temperature, °R.

UFAC, (0.5), specifies the amount of the previous station iteration u and T profiles to be mixed with the new iteration values of u and T at the stagnation point if more than twenty station iterations are required for a solution.

UINF, U_∞^* , freestream velocity, ft/sec.

WVFAC, (0.25), the amount of the new v profiles at each station to be mixed with the v profiles from the previous global iteration before the v profiles are written on disc or tape if the present global iteration is FVSL. Only third and subsequent global iterations are affected.

XKETA, (1.0), parameter which determines the spacing of the points of the finite-difference grid. A value of 1.0 gives uniform spacing, a value such as 1.04 gives more grid points near the body surface.

XLE, (1.4), Le , binary Lewis number.

XNSO, (0.1166), an initial value of the stagnation shock-layer thickness, used only for the first station iteration.

IE, (51), number of points in the finite difference grid in the normal direction.

IEND, (200), maximum number of solution stations in the streamwise direction. IEND should not exceed 200.

IGEOM, Indicator for body geometry;

1. hyperboloid
2. paraboloid
3. tabular data geometry

IUN, (19), input unit number for reaction rate data.
 JFAC, (1), indicator for axisymmetric (1) or two-dimensional (0) flow.
 KEND, (2), number of global iterations to be made.
 KPLTTP, (0), indicator which specifies whether plot data are to be written on Unit NTPL; 0, no; 1, yes.
 KTWAL, (0), indicator for input wall temperature distribution data on Unit NTTWA; 0, no; 1, yes.
 NAN, (1), indicator for analytic or near analytic bodies; 1, yes; 0, no. Negative values of NAN specify alternate methods of calculating the shock-layer thickness, XNS, as given in the description of Subroutine MASS.
 NDATA, (0), indicator for input of shock shape data on Unit NTSH; 0, no; 1, yes.
 NITMAX, (9999), number of station iterations permitted at a station before the s step size is halved and the program tries for a converged solution at the reduced value of s.
 NITMIN, (3), the s step size is doubled if a converged solution is obtained at a station in NITMIN or fewer station iterations.
 NITMNI, (3), the value assigned to NITMIN for the second and subsequent global iterations.
 NS, (2), number of species for the first global iteration; selects gas chemistry model; 2, binary reacting gas; 6, multicomponent reacting air.
 NSI, (2), value assigned to NS for second and subsequent global iterations.
 NSPRF, (0), number of values of s to be read into array SPRF at which specific solutions are to be obtained and profiles printed.
 NTSH, (5), Input Unit number for shock shape data arrays.
 NTTWA, (5), Input Unit number for wall temperature distribution arrays.

PREPARATION OF INPUT DATA

The principal guide to the user on preparing input data for the computer code is the section "Description of Input Data." This section describes steps which a user should follow in preparing input data for the program. It is suggested that the user cross reference this section with the section "Description of Input Data."

Minimum Input Data Required

Much of the input data for the program is optional. This subsection describes the minimum input data which the program requires. On logical unit 5 the program requires KTITLE (the title card), the NAMELIST INPUT, and the freestream and wall species concentration values for multicomponent air (CINF6 and CIWW6). Also required are the reaction rate data read by Subroutine RTEDTA on unit IUN which is initialized by the program (IUN = 19) but may be changed by the user as needed.

The bodies which can be treated with the minimum data required are analytic or nearly analytic bodies (e.g. hyperboloids and paraboloids) for which it may reasonably be assumed that the shock and body angles are the same for the first global iteration (that the pressure distribution is Newtonian). Also, for such a case, the step size should be held constant and DSMAX should equal DS in the INPUT data. For such a case (with NDATA = 0) the maximum value of s (surface distance) would be $DS \times (IEND + 1)$.

While most of the variables in the NAMELIST INPUT are initialized, some of the variables are not initialized and values of these variables must be provided. The noninitialized variables are ALT, the altitude; BRAD, the nose radius; RINF, the freestream density; TB, the surface temperature; TINF, the freestream temperature; UINF, the freestream velocity and IGEOM, the indicator for the body geometry. These variables are specific to a given case and must be assigned values in INPUT.

Shock Shape Data Input

With NDATA \neq 0, a shock shape can be input to the program. For hyperboloids (with shock and body angles equal) the requirements for a constant step size is thus removed. For some bodies it is not appropriate to use the assumption that shock and body angles are equal if the pressure distribution is non-Newtonian. A shock shape from a blunt body, method of characteristics procedure may work well. The user should follow two guidelines in preparing shock shape input data. First, the distributions shock slope (SHSLPN) and shock-layer thickness (ENSHN) should be smooth. Second, the spacing of the points (the array SN) should be quite small near the stagnation point but may increase gradually downstream (e.g. geometrically). In the stagnation region, the SN array should be a tenth of DS or smaller.

For a nearly analytic body, with a smooth contour and with continuous curvature, it may be permissible for the shock angle to equal the body angle for the shock data input. This would imply that the SHSLPN array would be zero and the ENSHN array constant.

Surface Temperature Input Data

The principal caution for the input of surface temperature data is that the spacing of the data points should change gradually and smoothly. Any large and abrupt changes in the distribution of the data points may cause difficulties in interpolating for the surface temperature and lead to erroneous results.

Input of Body Geometry Data

The program provides for tabular input of the body geometry data in Subroutine GEOM with IGEOM = 3. This option allows the user to consider bodies other than hyperboloids and paraboloids. Due care, however, must be exercised in the preparation of these data. The body contour must be smooth. Also, the distribution of the body angle or the derivative of r with respect to z must also be smooth. The spacing of the geometry points must be sufficiently small in the stagnation region (for several nose radii downstream of $s = 0$) to provide an accurate specification of the body contour. Since data points are required downstream of a solution location, the input arrays should provide geometry data to $s = \text{SEND} + 2\text{DSMAX}$. Finally, the body curvature must also have a smooth and continuous distribution. Accurate and complete specification of the surface contour is especially important since the shock shapes for the second and later global iterations are calculated from the body geometry, the body angle and the shock-layer thickness derivative.

Variable Values for Specific Conditions

Axisymmetric or Two-Dimensional flow is selected by the variable JFAC (1 or 0).

Body Geometry is specified by the variable IGEOM (1, hyperboloid; 2, paraboloid; and 3, tabular data geometry).

Fully Viscous Shock-Layer flow is specified by THINI = -1.0 (effective on the second and subsequent global iterations). THINI = 1.0 specifies Thin Viscous Shock-Layer flow after the first global iteration.

Gas Chemistry is specified by NS and NSI (for the first and subsequent global iterations, respectively). Values of 2 specify dissociating oxygen. Values of 6 specify multicomponent, ionizing air. Computing time is saved and little accuracy is lost if NS = 2 even if NSI = 6.

Nearly Analytic or analytic geometries are specified by $NAN = 1$. Non-analytic geometries are specified by zero or negative values of NAN . The options for $NAN \leq 0$ are described in the description of Subroutine MASS.

Shock Slip is specified by $SSFAC = 1.0$. No shock slip is specified by $SSFAC = -1.0$.

Wall Catalyticity is specified by the variable CAT . $CAT = -1.0$ specifies a noncatalytic wall (NCW) with $\left. \frac{\partial C_i}{\partial y} \right|_{wall} = 0$. $CAT = 1.0$ specifies a catalytic wall and the values of CAW and $CIWW6$ are used for dissociating oxygen and multicomponent air, respectively.

DESCRIPTION OF OUTPUT DATA

The principal printed output of the program is on Unit 6. Supplemental output of the program is on other units. The Unit 6 output is described followed by the output on the other units.

Unit 6 Output

At the beginning of the Unit 6 output, KTITLE, the case header card, is written. Following KTITLE, the NAMELIST INPUT, is printed. Some values of the NAMELIST variables may be reset between the reading and the printing of INPUT. The remaining Unit 6 output is repeated for each global iteration and within each global iteration the station output is repeated for each solution station.

The global iteration output begins with a listing of the reaction rate data subheader card followed by the reaction equations and reaction equation rate constants, the ALSUB, ALPHSB, BETSUB, BETASB arrays. Following is the ZSUB array if NZ is > 0.

After the reaction rate data the values of VSREF and VSINF (μ_{ref}^* and μ_∞^*) as calculated in the first section of subroutine THERM are printed.

At the beginning of each global iteration, after a converged station solution is obtained, header information to the global iteration is printed. The first line gives the following data.

UINF	U_∞^* , ft/sec, freestream velocity.
PINF	p_∞^* , lbf/ft ² , freestream static pressure.
TINF	T_∞^* , °R, freestream static temperature.
CAINF	C_{a_∞} , freestream oxygen atom concentration for the dissociating oxygen chemistry model.
TB	T_w , °R, wall temperature.
BRAD	R_n^* , ft, nose radius.
PR	Pr, Prandtl number.
LE	Le, binary Lewis number.
YSH	y_{sh} , at the stagnation point.
ALT	altitude, ft.

The second line describes the conditions and gives THIN SHOCK LAYER, (TVSL), or NO THIN SHOCK LAYER, (FVSL), NO WALL SLIP, NO SHOCK SLIP or SHOCK SLIP, CAT WALL, (ECW), or NO CAT WALL, (NCW), the number of steps in the y direction (IE), the maximum number of steps in the s direction (IEND), and the initial step size (DS).

The next line gives the values in the SPRF array if NSPRF > 0.

The final line gives the following data.

TW/TS T_w^*/T_o^* , ratio of wall to stagnation temperature, B0.
 EPS $\epsilon, \{\mu_{ref}^*/(\rho_\infty^* U_\infty^* R_n^*)\}^{1/2}$, Reynolds number parameter.
 REYIN $Re_\infty, \rho_\infty^* U_\infty^* R_n^*/\mu_\infty^*$, freestream Reynolds number based on the nose radius.
 REYSH $Re_{sh}, \rho_\infty^* U_\infty^* R_n^*/\mu_{sh}^*$, shock Reynolds number.
 TREF $T_{ref}^*, ^\circ R, U_\infty^{*2}/C_{p_\infty}^*$, reference temperature.
 UREF U_{ref}^* , ft/sec, reference velocity, U_∞^* .
 RREF ρ_{ref}^* , slugs/ft³, reference density, ρ_∞^* .
 ITER global iteration number.

The remaining output on Unit 6 is station output and for each solution station the output is similar. The station output begins (if PRINTCI = 0.0) with a line after each station iteration is completed giving K (the global iteration number), I (the station number), S (the streamwise location of the solution being attempted), NITER (the number of the station iteration) and DIFI (the maximum difference found for the u/u_{sh} , T/T_{sh} and C_i arrays, respectively). If, however, PRINTCI = 1.0, this line is replaced by an output array giving the same information with the y/y_{sh} (XN), u/u_{sh} (UC), T/T_{sh} (TC), the C_i arrays (headed by the species names), the sum of the C_i (SUMCI), the atom concentration sums for O (SUMO) and for N (SUMN).

After a converged solution is obtained, KTITLE is printed followed by the solution data for the station. For each station, four lines of output are printed. Additional output (profiles) are printed if s equals one of the values of the SPRF array or if I = 1, 6, 11, etc. (every fifth station).

LINE 1:

S s, surface distance.
 X x, axial coordinate to current surface point.
 R r_w , radial distance from the body axis to current surface point.

YSH y_{sh} , current shock-layer thickness, CNS.

YSHP derivative of y_{sh} with respect to s .

XSH x_{sh} , axial coordinate for the current shock point.

RSH r_{sh} , radial distance from the body axis to the current shock point.

NO ITER number of station iterations required to obtain the converged solution.

NITTOT total number of station iterations required for the current global iteration.

NTOT total number of station iterations required including those for any previous global iterations.

I I, the current station number.

K K, the current global iteration number.

LINE 2:

DS ds , step size in the s direction.

CF C_f , skin friction coefficient.

HEAT q_w , dimensionless heat transfer coefficient.

STAN St , $-q_w/(H_\infty - H_w)$, Stanton number, where H_w is the enthalpy at the wall if NS = 6 and if NS = 2 the wall enthalpy for O and O₂ in equilibrium.

CDF C_{Df} , the skin friction contribution to the drag coefficient.

CDP C_{Dp} , the pressure contribution to the drag coefficient.

CDTOT C_D , total drag coefficient.

PWALL P_w , (PC(1) x PPS), wall pressure.

TWALL T_w^* , $^{\circ}R$, wall temperature.

PW/PO $P_w/P_{w_{s=0}}$, ratio of wall pressure to wall pressure at the stagnation point.

LINE 3:

YSHP(S derivative of y_{sh} with respect to s at s from the SHSLPN array.

YSHP(S + DS/2 derivative of y_{sh} with respect to s at $s + ds/2$ from the SHSLPN array.

NEW YSHP derivative of y_{sh} with respect to s as calculated by the program.

ALPHA(S + DS/2 α , shock angle at $s + ds/2$.

PHI(S + DS/2 ϕ , body angle at $s + ds/2$.

KAPPA(S κ , body curvature at s .

KAPPA(S + DS/2 κ , body curvature at $s + ds/2$.

LINE 4:

USH u_{sh} , tangential velocity component behind the shock; first value U_{sh}^*/U_{ref}^* ; second value U_{sh} , ft/sec.

VSH v_{sh} , normal velocity component behind the shock; first value, V_{sh}^*/U_{ref}^* ; second value, V_{sh}^* , ft/sec.

TSH T_{sh} , temperature behind the shock; first value, T_{sh}^*/T_{ref}^* ; second value, T_{sh}^* , °R; third value, T_{sh}^* , °K.

RSH ρ_{sh} , density behind the shock.

PSH P_{sh} , pressure behind the shock.

VPG average of the derivatives of v_{sh} with respect to s at s and $s + ds/2$ from the previous global iteration.

The profile output is printed only if the value of s is one of the values of the SPRF array or if $I = 1, 6, 11$, etc. The first block of profile data is printed for both dissociating oxygen and for multicomponent air. The second block of profile data is printed only for multicomponent air.

The first block of profile data includes N , the grid point number; Y/YSH , the XN array; U/USH , the UC array, the tangential velocity profile; V/VSH , the VC array, the normal velocity profile; T/TSH , the TC array, the temperature profile; R/RSH , the RC array, the density profile; P/PSH (APPR) the PC array, the pressure profile; P/PSH , the PE array, an alternate pressure profile; CA , the $CC(N,1)$ array, the concentration profile of

oxygen atoms; CAEQ, the CAEQ array, the species concentration of atomic oxygen that would exist for dissociating oxygen at equilibrium; XM, the Mach number profile; and T °R, the temperature profile in degrees Rankine.

The second block of profile data includes N, the grid point number; Y/RN, y^*/R_n^* ; the species concentration profiles for O, O₂, NO, N, NO⁺ and N₂; E⁻/CC, the electron number density profiles; Y IN, y^* in inches; and Y²CM, y^* in centimeters.

Unit 1 Output

The program output on Unit 1 provides convenient access to principle data generated by the program as a function of s. The following data are printed for each converged solution.

K	the global iteration number.
I	the station number.
S/RN	$s = s^*/R_n^*$, surface distance.
ITER	the number of station iterations needed to obtain a converged solution at that value of s.
YSH	y_{sh} , shock layer thickness, XNS.
YSHP	the calculated derivative of y_{sh} with respect to s, XNSP(I).
CF	C_f , the skin friction coefficient, CFCH.
HEAT	q_w , the nondimensionalized heat transfer.
STAN	St, Stanton number.
PW/PO	ratio of P_w to P_w at the stagnation point.
Q/QO	ratio of q_w to q_w at the stagnation point.
S	s^* , ft, surface distance.
QDOT	q_w^* , heat transfer, BTU/ft ² sec.

Unit 3 Output

The output for Unit 3 is similar in approach to that on Unit 1 but of different content.

K the global iteration number.
 I the station number.
 ITER the number of station iterations needed to obtain a converged solution at the value of s .
 S/RN s^*/R_n^* , surface distance.
 YSH y_{sh} , the shock-layer thickness, XNS.
 YSH-D y_{sh} as calculated from the integration of the mass conservation equation.
 YSH-ST y_{sh} as calculated by matching the mass flow through the shock with the mass flow through the shock layer.
 YSH-AV y_{sh} as the average of YSH-D and YSH-ST.
 E-/CC,MAX the peak value of the electron number density.
 XN,E-MAX the value of y/y_{sh} corresponding to the peak N_e/cm^3 .
 Y,IN,E-M the value of y^* , in inches, corresponding to the peak N_e/cm^3 .
 S/RN s^*/R_n^* , surface distance.
 S FT s^* , ft, surface distance.

Unit 8 Output

The output on Unit 8 is divided into two groups. The first group is printed only if $\text{NDATA} \neq 0$; that is, if shock shape data are input to the program.

The first group of output data consists of S , s^*/R_n^* , the surface distance (the array SN); YSHP, the corresponding derivative of y_{sh} with respect to s (the array SHSLPN); and N , the array subscript.

The second group of output data is written line by line as solutions are obtained. The first part of the line is written before a solution at the given station is attempted. The second part of the line is written after a converged solution is obtained at the given station. The data for the first part of the line are as follows.

STA. NO. I, the station number.
 S s , surface distance.

OLDXNSP y'_{sh} (the derivative of y_{sh} with respect to s) at s from the previous global iteration or from the array SHSLPN.

XNSPM y'_{sh} at $s + ds/2$ from the previous global iteration or from the array SHSLPN.

ALPHA(S+DS/2) α , the shock angle at $s + ds/2$.

The remainder of the line is printed after a converged station solution is obtained. These data are:

NEW XNSP the new value of y'_{sh} computed by the program.

NEW YSH y_{sh} , XNS, computed by the program.

XSH x coordinate of the shock point.

RSH r coordinate of the shock point.

Unit 9 Output

At the end of each station iteration the following data are printed on Unit 9.

K global iteration number.

I the station number.

S s , the surface distance.

NITER the number of iterations at that station.

NITTOT the total number of station iterations for the global iteration.

TFACT a primitive convergence criterion $U2(15)$ old - $U2(15)$ new iteration.

DIF maximum difference for the velocity profiles between station iteration.

(unnamed) XNS, the current station iteration value of y_{sh} .

(unnamed) CNS, the average of XNS and y_{sh} at the previous station or, if $s = 0$, from the previous station iteration.

Unit NTPL Output

After a converged station solution is obtained, the following data are written unformatted on Unit NTPL (13) in Subroutine RESET if KPLTTP \neq 0 for plotting or other purposes appropriate to the user:

K	global iteration number.
I	station number.
XSOL(I)	s, the surface distance of the solution point.
XB	x_w , axial coordinate of the solution point.
RS	r_w , radial coordinate of the solution point.
XSH	x_{sh} , axial coordinate of the shock point.
RSH	r_{sh} , radial coordinate of the shock point.
CNS	y_{sh} , shock-layer thickness.
CFCH	C_f , skin friction coefficient.
STAN	St, Stanton number.
PWRAT	ratio of P_w to P_w at the stagnation point.

APPENDIX A: ANALYSIS

This appendix presents in an abbreviated form the analysis of the viscous, shock-layer problem as given in the companion engineering report. The equations are written for a body oriented coordinate system as shown in Fig. 3. Unless indicated otherwise, variables using a superscript star (*) are dimensional and unstarred variables are nondimensional.

Governing Equations

The equations for shock-layer flows of multicomponent gases are given below.

Continuity Equation:

$$\frac{\partial}{\partial s} \{ (r + y \cos \phi)^j \rho u \} + \frac{\partial}{\partial y} \{ (1 + \kappa y) (r + y \cos \phi)^j \rho v \} = 0 \quad (1)$$

s-Momentum Equation:

$$\begin{aligned} \frac{1}{1+\kappa y} \rho u \frac{\partial u}{\partial s} + \rho v \frac{\partial u}{\partial y} + \rho uv \frac{\kappa}{1+\kappa y} + \frac{1}{1+\kappa y} \frac{\partial P}{\partial s} = \epsilon^2 \frac{\partial}{\partial y} \left[\mu \left(\frac{\partial u}{\partial y} - \frac{\kappa u}{1+\kappa y} \right) \right] + \\ \epsilon^2 \mu \left(\frac{2\kappa}{1+\kappa y} + \frac{j \cos \phi}{r + y \cos \phi} \right) \left(\frac{\partial u}{\partial y} - \frac{\kappa u}{1+\kappa y} \right) \end{aligned} \quad (2)$$

y-Momentum Equation:

$$\frac{\partial P}{\partial y} = \frac{\kappa}{1+\kappa y} \rho u^2 - \frac{1}{1+\kappa y} \rho u \frac{\partial v}{\partial s} - \rho v \frac{\partial v}{\partial y} \quad (\text{FVSL}) \quad (3a)$$

which becomes

$$\frac{\partial P}{\partial y} = \frac{\kappa}{1+\kappa y} \rho u^2 \quad (\text{TVSL}) \quad (3b)$$

if the thin shock-layer approximation is made.

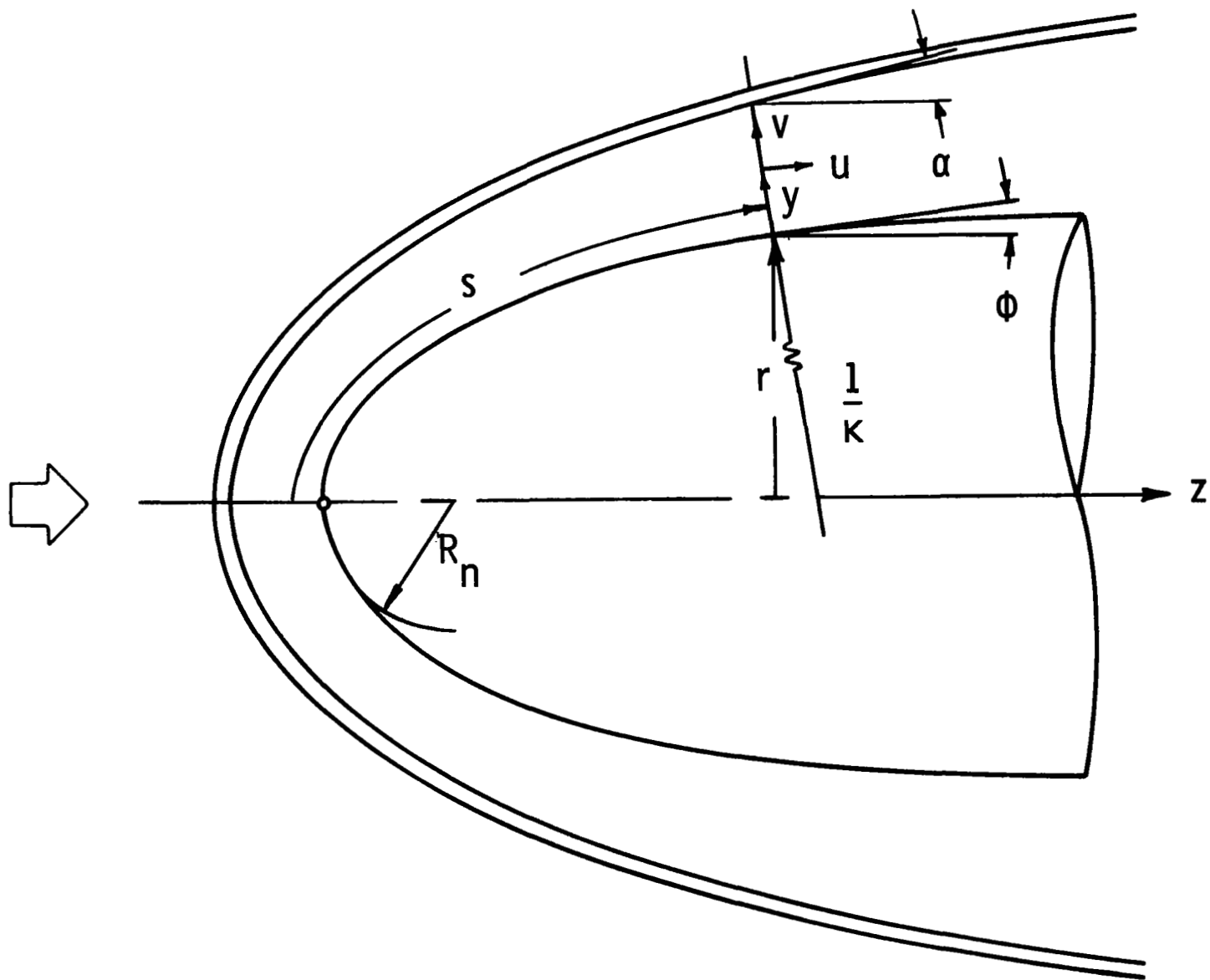


Figure 3. Coordinate System for Viscous Shock-Layer Over Blunt Bodies.

Energy Equation:

$$\begin{aligned} \frac{1}{1+\kappa y} \rho u C_p \frac{\partial T}{\partial s} + \rho v C_p \frac{\partial T}{\partial y} - \frac{1}{1+\kappa y} u \frac{\partial P}{\partial s} - v \frac{\partial P}{\partial y} = \\ \epsilon^2 \frac{\partial}{\partial y} \left(k \frac{\partial T}{\partial y} \right) + \epsilon^2 \left(\frac{\kappa}{1+\kappa y} + \frac{j \cos \phi}{r + y \cos \phi} \right) k \frac{\partial T}{\partial y} - \epsilon^2 \sum_{i=1}^{ns} J_i C_{p_i} \frac{\partial T}{\partial y} + \\ \epsilon^2 \mu \left(\frac{\partial u}{\partial y} - \frac{\kappa u}{1+\kappa y} \right)^2 - \sum_{i=1}^{ns} h_i \dot{w}_i \quad (4) \end{aligned}$$

Species Conservation Equations:

$$\frac{1}{1+\kappa y} \rho u \frac{\partial C_i}{\partial s} + \rho v \frac{\partial C_i}{\partial y} = \dot{w}_i - \epsilon^2 \frac{\partial}{\partial y} (J_i) - \epsilon^2 \left(\frac{\kappa}{1+\kappa y} + \frac{j \cos \phi}{r + y \cos \phi} \right) J_i \quad (5)$$

where J_i is the diffusion mass flux term of species i , and

Equation of State:

$$P = \frac{\rho R T}{M C_{p\infty}^*} \quad (6)$$

With binary diffusion only and with constant binary Lewis numbers (all equal), the diffusion mass flux term of the species is given by

$$J_i = - \frac{\mu}{Pr} Le_i \frac{\partial C_i}{\partial y} \quad (7)$$

The species mass fractions are given by

$$C_i = \rho_i / \rho \quad (8)$$

The frozen specific heat of the mixture is given by

$$C_p = \sum_{i=1}^{ns} C_i C_{p_i} \quad (9)$$

and the mixture molecular weight is given by

$$\bar{M} = \frac{1}{ns \sum_{i=1} \frac{C_i}{\bar{M}_i}} \quad (10)$$

The preceding equations are nondimensional. The dimensional equations were nondimensionalized by the following relations:

$$u^* = u U_{\infty}^* \quad (11a)$$

$$v^* = v U_{\infty}^* \quad (11b)$$

$$T^* = T T_{\text{ref}}^* = T U_{\infty}^{*2} / C_{p\infty}^* \quad (11c)$$

$$p^* = p \rho_{\infty}^* U_{\infty}^{*2} \quad (11d)$$

$$\rho^* = \rho \rho_{\infty}^* \quad (11e)$$

$$\mu^* = \mu \mu_{\text{ref}}^* \quad (11f)$$

$$k^* = k \mu_{\text{ref}}^* C_{p\infty}^* \quad (11g)$$

$$C_p^* = C_p C_{p\infty}^* \quad (11h)$$

$$h^* = h U_{\infty}^{*2} \quad (11i)$$

$$w_i^* = w_i \rho_{\infty}^* U_{\infty}^{*2} / R_n^* \quad (11j)$$

$$J_i^* = J_i \mu_{\text{ref}}^* / R_n^* \quad (11k)$$

$$s^* = s R_n^* \quad (11l)$$

$$y^* = y R_n^* \quad (11m)$$

$$\kappa^* = \kappa R_n^* \quad (11n)$$

and

$$r^* = r R_n^* \quad (11o)$$

The dimensionless parameters which appear in the shock-layer equations are given by the following relations:

$$Pr = C_p^* \mu^* / k^* \quad (12a)$$

$$\epsilon = \sqrt{\frac{\mu_{ref}^*}{\rho_{\infty}^* U_{\infty}^* R_n^*}} \quad (12b)$$

and

$$Le_i = \rho^* C_p^* D_i^* / k^* \quad (12c)$$

For the finite-difference solution procedure, the shock-layer equations were transformed. The independent and dependent variables (except for the species concentrations) were normalized by their local shock values.

The transformed independent and dependent variables are

$$\eta = y/y_{sh} \quad (13a)$$

$$\xi = s \quad (13b)$$

$$\bar{u} = u/u_{sh} \quad (13c)$$

$$\bar{v} = v/v_{sh} \quad (13d)$$

$$\bar{P} = P/P_{sh} \quad (13e)$$

$$\bar{\rho} = \rho/\rho_{sh} \quad (13f)$$

$$\bar{T} = T/T_{sh} \quad (13g)$$

$$\bar{\mu} = \mu/\mu_{sh} \quad (13h)$$

$$\bar{k} = k/k_{sh} \quad (13i)$$

and

$$\bar{C}_p = C_p/C_{p_{sh}} \quad (13j)$$

The transformations relating the differential expressions are

$$\frac{\partial}{\partial s} = \frac{\partial}{\partial \xi} - \frac{y'_{sh}}{y_{sh}} \eta \frac{\partial}{\partial \eta} \quad (14a)$$

$$\frac{\partial}{\partial y} = \frac{1}{y_{sh}} \frac{\partial}{\partial \eta} \quad (14b)$$

and

$$\frac{\partial^2}{\partial y^2} = \frac{1}{y_{sh}^2} \frac{\partial^2}{\partial \eta^2} \quad (14c)$$

where

$$y'_{sh} = \frac{dy_{sh}}{d\xi} \quad (14d)$$

When written in the transformed ξ, η coordinates, the s-momentum, energy and species continuity equations (Eqs. 2, 4 and 5) can be expressed in the following standard form for a parabolic partial differential equation:

$$\frac{\partial^2 W}{\partial \eta^2} + A_1 \frac{\partial W}{\partial \eta} + A_2 W + A_3 + A_4 \frac{\partial W}{\partial \xi} = 0 \quad (15)$$

where W represents \bar{u} in the s momentum equation, \bar{T} in the energy equation and C_i in the species continuity equations. The coefficients A_1 through A_4 are functions of the independent and dependent variables and may be written as follows:

s-momentum equation

$$A_1 = \frac{1}{\mu} \frac{\partial \bar{\mu}}{\partial \eta} + \frac{\kappa y_{sh}}{1 + \kappa y_{sh} \eta} + \frac{j y_{sh} \cos \phi}{r + y_{sh} \eta \cos \phi} + \frac{y_{sh} y'_{sh} \rho_{sh} u_{sh}}{\epsilon^2 \mu_{sh} (1 + \kappa y_{sh} \eta)} \frac{\bar{\rho u \eta}}{\bar{\mu}} - \frac{y_{sh} \rho_{sh} v_{sh}}{\epsilon^2 \mu_{sh}} \frac{\bar{\rho v}}{\bar{\mu}} \quad (16a)$$

$$A_2 = - \frac{\kappa y_{sh}}{1 + \kappa y_{sh} \eta} \frac{1}{\mu} \frac{\partial \bar{\mu}}{\partial \eta} - \frac{\kappa^2 y_{sh}^2}{(1 + \kappa y_{sh} \eta)^2} - \frac{\kappa y_{sh}^2 j \cos \phi}{(1 + \kappa y_{sh} \eta) (r + y_{sh} \eta \cos \phi)} - \frac{y_{sh}^2 \rho_{sh} u'_{sh}}{\epsilon^2 \mu_{sh} (1 + \kappa y_{sh} \eta)} \frac{\bar{\rho u}}{\bar{\mu}} - \frac{\kappa y_{sh}^2 \rho_{sh} v_{sh}}{\epsilon^2 \mu_{sh} (1 + \kappa y_{sh} \eta)} \frac{\bar{\rho v}}{\bar{\mu}} \quad (16b)$$

$$A_3 = - \frac{y_{sh}^2}{\epsilon^2 \mu_{sh} u_{sh} (1+\kappa y_{sh} \eta) \bar{\mu}} \left[\bar{P} \frac{\partial P_{sh}}{\partial \xi} + P_{sh} \frac{\partial \bar{P}}{\partial \xi} - \eta \frac{y'_{sh}}{y_{sh}} P_{sh} \frac{\partial \bar{P}}{\partial \eta} \right] \quad (16c)$$

$$A_4 = - \frac{y_{sh}^2 \rho_{sh} u_{sh}}{\epsilon^2 \mu_{sh} (1+\kappa y_{sh} \eta) \bar{\mu}} \quad (16d)$$

Energy Equation

$$A_1 = \frac{1}{\bar{k}} \frac{\partial \bar{k}}{\partial \eta} + \frac{\kappa y_{sh}}{1+\kappa y_{sh} \eta} + \frac{y_{sh} j \cos \phi}{r + y_{sh} \eta \cos \phi} - \frac{y_{sh}}{k_{sh} \bar{k}} \sum_{i=1}^{ns} J_i C_{p_i} - \frac{y_{sh} \rho_{sh} C_{p_i} \bar{\rho} \bar{C}_p}{\epsilon^2 k_{sh} \bar{k}} \left[v_{sh} \bar{v} - \frac{u_{sh} y'_{sh} \bar{u} \eta}{1+\kappa y_{sh} \eta} \right] \quad (17a)$$

$$A_2 = A_4 \frac{1}{T_{sh}} \frac{\partial T_{sh}}{\partial \xi} - \frac{y_{sh}^2 \dot{w}_2}{\epsilon^2 k_{sh} \bar{k}} \quad (17b)$$

$$A_3 = - \frac{y_{sh}^2 \dot{w}_1}{\epsilon^2 T_{sh} k_{sh} \bar{k}} + \frac{y_{sh}^2 \mu_{sh} \bar{\mu}}{T_{sh} k_{sh} \bar{k}} \left[\frac{u_{sh}}{y_{sh}} \frac{\partial \bar{u}}{\partial \eta} - \frac{\kappa u_{sh} \bar{u}}{1+\kappa y_{sh} \eta} \right]^2 + \frac{y_{sh} u_{sh} \bar{u}}{\epsilon^2 (1+\kappa y_{sh} \eta) T_{sh} k_{sh} \bar{k}} \left[y_{sh} \bar{P} \frac{\partial P_{sh}}{\partial \xi} + y_{sh} P_{sh} \frac{\partial \bar{P}}{\partial \xi} - y'_{sh} P_{sh} \eta \frac{\partial \bar{P}}{\partial \eta} \right] + \frac{y_{sh} P_{sh} v_{sh} \bar{v}}{\epsilon^2 T_{sh} k_{sh} \bar{k}} \frac{\partial \bar{P}}{\partial \eta} \quad (17c)$$

$$A_4 = - \frac{y_{sh}^2 C_{psh} \rho_{sh} u_{sh}}{\epsilon^2 (1+\kappa y_{sh} \eta) k_{sh}} \frac{\bar{C}_p \bar{\rho} \bar{u}}{\bar{k}} \quad (17d)$$

Species Conservation Equation

$$A_1 = \frac{1}{JB} \frac{\partial JB}{\partial \eta} + \frac{y_{sh} \kappa}{1 + \kappa y_{sh} \eta} + \frac{y_{sh} j \cos \phi}{r + y_{sh} \eta \cos \phi} - \frac{y_{sh} \rho_{sh} v_{sh} \overline{\rho v}}{\epsilon^2 JB} + \frac{y_{sh} y'_{sh} \rho_{sh} u_{sh} \overline{\rho u} \eta}{\epsilon^2 JB (1 + \kappa y_{sh} \eta)} \quad (18a)$$

$$A_2 = - \frac{y_{sh}^2 \rho_{sh} \overline{\rho} w_i^1}{\epsilon^2 JB} \quad (18b)$$

$$A_3 = \frac{y_{sh}^2 \rho_{sh} \overline{\rho} w_i^0}{\epsilon^2 JB} \quad (18c)$$

$$A_4 = - \frac{y_{sh}^2 \rho_{sh} u_{sh} \overline{\rho u}}{\epsilon^2 JB (1 + \kappa y_{sh} \eta)} \quad (18d)$$

where

$$JB = \frac{\mu_{sh} \overline{\mu} Le_i}{Pr_{sh} \overline{Pr}} \quad (18e)$$

In the transformed coordinates the remaining equations are

Continuity Equation

$$\frac{\partial}{\partial \xi} \left[y_{sh} (r + y_{sh} \eta \cos \phi)^j \rho_{sh} u_{sh} \overline{\rho u} \right] = \frac{\partial}{\partial \eta} \left[(r + y_{sh} \eta \cos \phi)^j \{ y'_{sh} \rho_{sh} u_{sh} \overline{\rho u} \eta - (1 + \kappa y_{sh} \eta) \rho_{sh} v_{sh} \overline{\rho v} \} \right] \quad (19)$$

y-momentum equation

$$\frac{P_{sh}}{y_{sh} \rho_{sh} u_{sh} v_{sh}} \frac{\partial \bar{P}}{\partial \eta} - \frac{\kappa u_{sh}}{v_{sh} (1 + \kappa y_{sh} \eta)} \bar{\rho u}^2 + \frac{v_{sh} \bar{\rho v}}{y_{sh} u_{sh}} \frac{\partial \bar{v}}{\partial \eta} + \frac{\bar{\rho u}}{1 + \kappa y_{sh} \eta} \left[\frac{\partial \bar{v}}{\partial \xi} + \frac{\bar{v}}{v_{sh}} \frac{\partial v_{sh}}{\partial \xi} - \frac{y'_{sh} \eta}{y_{sh}} \frac{\partial \bar{v}}{\partial \eta} \right] = 0 \quad (20a)$$

which becomes

$$\frac{\partial \bar{P}}{\partial \eta} = \frac{\kappa y_{sh} \rho_{sh} u_{sh}^2}{P_{sh} (1 + \kappa y_{sh} \eta)} \bar{\rho u}^2 \quad (20b)$$

if the thin shock-layer approximation is made, and

State Equation

$$\bar{P} = \bar{\rho} \bar{T} \frac{\bar{M}_{sh}}{\bar{M}} \quad (21)$$

The energy and species conservation equations (Eqs. 4 and 5) include the rate of production terms, \dot{w}_i , of species i . For the energy equation, the production term is written so that the temperature appears as an unknown as

$$\left(\frac{\dot{w}_i}{\rho} \right)_{k+1} = \left(\frac{\dot{w}_i}{\rho} \right)_k + \left[\frac{\partial}{\partial T} \left(\frac{\dot{w}_i}{\rho} \right) \right]_k [T_{k+1} - T_k] \quad (22)$$

where k denotes the iteration for which the solution is known and $k+1$ the iteration for which a solution is sought. The production term in the energy equation (Eq. 4) was rewritten as

$$\sum_{i=1}^{ns} h_i \dot{w}_i = \dot{w}_1 + T_{sh} \bar{T} \dot{w}_2 \quad (23)$$

and the terms \dot{w}_1 and \dot{w}_2 appear in the energy equation coefficients (Eqs. 17b and 17c). For the species conservation equation, the production term was written so that the species mass fractions appear as an unknown as

$$\frac{\dot{w}_i}{\rho} = \dot{w}_i^0 - C_i \dot{w}_i^1 \quad (24)$$

and the terms \dot{w}_i^0 and \dot{w}_i^1 appear in the species conservation equation coefficients (Eqs. 18b and 18c).

The viscous shock layer for nonequilibrium chemistry is described by equations (15) through (21) together with the appropriate boundary conditions and relations for the thermodynamic and transport properties.

Boundary Conditions

At the body surface, the no slip boundary conditions are imposed. For $\eta = 0$, the surface conditions are

$$\bar{u} = 0 \quad (25a)$$

$$\bar{v} = 0 \quad (25b)$$

and

$$T = T_w \quad (25c)$$

where T_w is either a constant or has a specified variation. For a noncatalytic surface, (NCW), the species boundary conditions are

$$\frac{\partial C_i}{\partial \eta} = 0 \quad (25d)$$

The equilibrium catalytic wall (ECW) conditions are specified by

$$C_i = C_{i_{eq}}(T_w) \quad (25e)$$

In the program the ECW condition is approximated by a fully catalytic surface (FCW) condition specified by, for example,

$$C_O = 0, C_{O_2} = 0.23456, C_{NO} = 0, C_N = 0, C_{NO^+} = 0 \text{ and } C_{N_2} = 0.76544 \quad (25f)$$

At the shock, the velocity components tangent and normal to the shock are not the same as the components tangent and normal to the body surface. The velocity components tangent and normal to the shock are denoted by \hat{u}_{sh} and \hat{v}_{sh} and the components tangent and normal to the body surface are denoted as u_{sh} and v_{sh} . The transformation relating the two sets of shock velocity components is

$$u_{sh} = \hat{u}_{sh} \sin(\alpha + \beta) + \hat{v}_{sh} \cos(\alpha + \beta) \quad (26a)$$

and

$$v_{sh} = -\hat{u}_{sh} \cos(\alpha + \beta) + \hat{v}_{sh} \sin(\alpha + \beta) \quad (26b)$$

where $\beta = \pi/2 - \phi$.

For shocks of finite thickness called shock slip (SS), the shock properties are given by the modified Rankine-Hugoniot relations (see Davis and Cheng) below.

$$\rho_{sh} \hat{v}_{sh} = -\sin \alpha \quad (27a)$$

$$\epsilon^2 \mu_{sh} \left(\frac{\partial \hat{u}}{\partial y} \right)_{sh} + \sin \alpha \hat{u}_{sh} = \sin \alpha \cos \alpha \quad (27b)$$

$$P_{sh} - \sin \alpha \hat{v}_{sh} = \frac{P_{\infty}}{\rho_{\infty} U_{\infty}^2} + \sin^2 \alpha \quad (27c)$$

$$\begin{aligned} \epsilon^2 k_{sh} \left(\frac{\partial T}{\partial y} \right)_{sh} + \sin \alpha \sum_{i=1}^{ns} C_{i_{\infty}} h_{i_{sh}} - \frac{\sin \alpha}{2} \{ (\hat{u}_{sh} - \cos \alpha)^2 + \sin^2 \alpha - \hat{v}_{sh} \} \\ = \sin \alpha \sum_{i=1}^{ns} C_{i_{\infty}} h_{i_{\infty}} \end{aligned} \quad (27d)$$

and

$$\epsilon^2 \frac{\mu_{sh}}{Pr_{sh}} Le_i \frac{\partial C_{i_{sh}}}{\partial y} + \sin \alpha C_{i_{sh}} = \sin \alpha C_{i_{\infty}} \quad (27e)$$

With no shock slip (NSS) the Rankine-Hugoniot relations are used to determine the shock values. Eqs. (27a) and (27c) are unchanged. The expressions for \hat{u}_{sh} , T_{sh} and $C_{i_{sh}}$ become

$$\hat{u}_{sh} = \cos \alpha \quad (28a)$$

$$\sum_{i=1}^{ns} c_{i_{\infty}} h_{i_{sh}} - (\hat{u}_{sh} - \cos \alpha)^2/2 + (\sin^2 \alpha - \hat{v}_{sh})/2 = \sum_{i=1}^{ns} c_{i_{\infty}} h_{i_{\infty}} \quad (28b)$$

and

$$c_{i_{sh}} = c_{i_{\infty}} \quad (28c)$$

The shock conditions for the dependent variables (at $y = 1$) are

$$\bar{u} = \bar{v} = \bar{\rho} = \bar{p} = \bar{T} = 1 \quad (29a)$$

and

$$c_i = c_{i_{sh}} \quad (29b)$$

Surface Transport

The surface skin friction and heat transfer rates are given by the skin friction coefficient and Stanton number. The skin friction coefficient is given by

$$C_f = \frac{2\tau_w^*}{\rho_{\infty}^* U_{\infty}^{*2}} \quad (30a)$$

where

$$\tau_w^* = \left[\mu^* \frac{\partial u^*}{\partial y^*} \right]_w \quad (30b)$$

In terms of the nondimensionalized variables, the skin friction coefficient is given by

$$C_f = 2\epsilon^2 \left[\mu \frac{\partial u}{\partial y} \right]_w \quad (30c)$$

The Stanton number is given by the expression

$$St = \frac{q_w^*}{\rho_\infty^* V_\infty^* (H_\infty^* - H_w^*)} \quad (31a)$$

or in the dimensionless variables

$$St = \frac{q_w}{H_\infty - H_w} \quad (31b)$$

where

$$q_w^* = - \left[k^* \frac{\partial T^*}{\partial y^*} - \sum_{i=1}^{ns} h_i^* J_i^* \right]_w \quad (31c)$$

and

$$q_w = -\epsilon^2 \left[k \frac{\partial T}{\partial y} - \sum_{i=1}^{ns} h_i J_i \right]_w \quad (31d)$$

or

$$q_w = -\epsilon^2 \left[k \frac{\partial T}{\partial y} + \sum_{i=1}^{ns} \frac{\mu}{Pr} Le_i h_i \frac{\partial C_i}{\partial y} \right]_w \quad (31e)$$

with the restriction of constant and equal Lewis numbers.

Thermodynamic and Transport Properties

The program has tables of species enthalpy and specific heat in the form

$$\hat{H}_i = \frac{h_i - \Delta h_i^F}{T} ; \text{ ft}^2/\text{sec}^2\text{-}^\circ\text{R} \quad (32a)$$

and

$$\hat{C}_{p_i} = C_p ; \text{ ft}^2/\text{sec}^2\text{-}^\circ\text{R} \quad (32b)$$

Second order Lagrangian interpolation is used to obtain the values of \hat{H}_i and \hat{C}_{p_i} from the tables. The species enthalpy and specific heat are then calculated from the expressions

$$h_i = T \hat{H}_i + \Delta h_i^F; \text{ ft}^2/\text{sec}^2 \quad (33a)$$

and

$$C_{p_i} = \hat{C}_{p_i}; \text{ ft}^2/\text{sec}^2\text{-}^\circ\text{R} \quad (33b)$$

where Δh_i^F is the heat of formation of species i.

The viscosity of each of the individual species is calculated from the curve fit relation

$$\mu_i = \exp(C_i) T_k^{(A_i \ln T_k + B_i)}; \frac{\text{gm}}{\text{cm-sec}} \quad (34)$$

where A_i , B_i and C_i are the curve fit constants for the species and T_k is the local temperature in degrees Kelvin. The units of the species viscosity are converted to lbf-sec/ft².

The thermal conductivity of the individual species is calculated from the expression

$$k_i = \frac{\mu_i R}{M_i} \left(\frac{C_{p_i} M_i}{R} + \frac{5}{4} \right); \frac{\text{lbf}}{\text{sec-}^\circ\text{R}} \quad (35)$$

After the viscosity and thermal conductivity of the individual species are calculated, the viscosity and thermal conductivity of the mixture are calculated using Wilke's semi-empirical relations;

$$\mu = \sum_{i=1}^{ns} \left(\frac{X_i \mu_i}{\sum_{j=1}^{ns} X_i \phi_{ij}} \right); \frac{\text{lbf-sec}}{\text{ft}^2} \quad (36)$$

$$k = \sum_{i=1}^{ns} \left(\frac{X_i k_i}{\sum_{j=1}^{ns} X_i \phi_{ij}} \right); \frac{\text{lbf}}{\text{sec-}^\circ\text{R}} \quad (37)$$

where $X_i = C_i \bar{M}/M_i$

$$\text{and } \phi_{ij} = \left[1 + \left(\frac{\mu_i}{\mu_j} \right)^{1/2} \left(\frac{M_j}{M_i} \right)^{1/4} \right]^2 \left[\sqrt{8} \left(1 + \frac{M_i}{M_j} \right)^{1/2} \right]^{-1}$$

In the program, the diffusion model is limited to binary diffusion with the binary diffusion coefficients specified by the Lewis number from Eq. (12c).

$$Le_i = \rho C_p D_i / k$$

The values of the Lewis numbers used are 1.4.

Chemical Reaction Model

In the program, the chemical model assumes reactions proceeding at a finite rate, and the rate of production terms, \dot{w}_i , of the individual species are needed. The production terms occur in the energy equation (Eq. 4) and the species conservation equations (Eq. 5). For a multicomponent gas with n_s distinct chemical species and n_r simultaneous chemical reactions, the chemical reaction equations are written in the general stoichiometric form

$$\sum_{i=1}^{n_j} \alpha_{ri} X_i \xrightleftharpoons[k_{b_r}]{k_{f_r}} \sum_{i=1}^{n_j} \beta_{ri} X_i \quad (38)$$

where $r = 1, 2, \dots, n_r$ and n_j is equal to the sum of the species and the catalytic third bodies. The quantities X_i represent the chemical species and the catalytic third bodies, and the α_{ri} and β_{ri} are the stoichiometric coefficients for reactants and products. The rates at which the forward and backward reactions occur are specified by the forward and backward rate constants which are given by the equations

$$k_{f_r} = T_k^{C2_r} \exp (C0_r - C1_r/T_k) \quad (39a)$$

and

$$k_{b_r} = T_k^{D2_r} \exp (D0_r - D1_r/T_k) \quad (39b)$$

where T_k is the temperature in degrees Kelvin and $C0_r$, $C1_r$, $C2_r$, $D0_r$, $D1_r$, and $D2_r$ are tabular constants.

With the forward and backward reaction rate constants given by Eq. (39) the net mass rate of production of species i per unit volume, \dot{w}_i , is given by the equation

$$\frac{\dot{w}_i}{\rho} = M_i \sum_{r=1}^{n_r} (\beta_{ri} - \alpha_{ri}) (L_{f_r} - L_{b_r}) \quad (40)$$

where

$$\alpha_r = \sum_{j=1}^{n_j} \alpha_{rj} - 1$$

$$\beta_r = \sum_{j=1}^{n_j} \beta_{rj} - 1$$

$$L_{fr} = k_{fr} \bar{\rho}^{-\alpha_r} \prod_{j=1}^{n_j} (\gamma_j)^{\alpha_{rj}}$$

$$L_{br} = k_{br} \bar{\rho}^{-\beta_r} \prod_{j=1}^{n_j} (\gamma_j)^{\beta_{rj}}$$

$$\bar{\rho} \text{ (gm/cm}^3\text{)} = 0.51536 \rho \text{ (slugs/ft}^3\text{)}$$

For the ns species the mass concentrations γ_j are given by the expressions

$$\gamma_j = \frac{C_j}{M_j} \quad j = 1, 2, \dots, ns$$

whereas for the catalytic third bodies the γ_j are given by the following expressions

$$\gamma_j = \sum_{i=1}^{ns} Z_{(j-ns),i} \gamma_i \quad j = (ns+1), \dots, nj$$

The quantity $Z_{(j-ns),i}$ is the third body efficiency relative to argon and is determined from the reaction being considered.

Rewritten so that the species concentrations appear as one of the unknowns, the rate of production terms are given by the expression

$$\frac{\dot{w}_i}{\rho} = \dot{w}_i^0 - \dot{w}_i^1 C_i \quad (24)$$

where

$$\dot{w}_i^0 = \mu_i \sum_{r=1}^{nr} (\Gamma_{ri}^+ L_{fr} + \Gamma_{ri}^- L_{br}) \quad (41a)$$

$$\dot{w}_i^1 = \sum_{r=1}^{nr} \{\Gamma_{ri}^+ (L_{br}/\gamma_i) + \Gamma_{ri}^- (L_{fr}/\gamma_i)\} \quad (41b)$$

$$\Gamma_{ri}^+ = \begin{cases} (\beta_{ri} - \alpha_{ri}) & \text{if } (\beta_{ri} - \alpha_{ri}) > 0 \\ 0 & \text{if } (\beta_{ri} - \alpha_{ri}) \leq 0 \end{cases}$$

$$\Gamma_{ri}^- = \begin{cases} 0 & \text{if } (\beta_{ri} - \alpha_{ri}) \geq 0 \\ -(\beta_{ri} - \alpha_{ri}) & \text{if } (\beta_{ri} - \alpha_{ri}) < 0 \end{cases}$$

With temperature in degrees Kelvin, T_k , the expression for the derivative of \dot{w}_i/ρ with respect to T is

$$\frac{\partial}{\partial T_k} \left(\frac{\dot{w}_i}{\rho} \right) = \frac{M_i}{T_k} \sum_{r=1}^{nr} (\beta_{ri} - \alpha_{ri}) \{ (C2_r + C1_r/T_k - \alpha_r) L_{fr} - (D2_r + D1_r/T_k - \beta_r) L_{br} \} \quad (42)$$

Method of Solution

A finite-difference method is used to solve the governing differential equations for the viscous shock-layer flows. The solutions for the continuity and n-momentum equations are obtained by integration with the trapezoidal rule. The s-momentum, energy and species conservation equations are expressed in the standard form for a parabolic partial differential equation

$$\frac{\partial^2 W}{\partial \eta^2} + A_1 \frac{\partial W}{\partial \eta} + A_2 W + A_3 + A_4 \frac{\partial W}{\partial \xi} = 0 \quad (15)$$

These equations are solved using the algorithm described by Davis.

Solution for S-Momentum, Energy and Species Conservation Equations

With the finite-difference grid as shown in Fig. 4, Taylor series expansions are used to relate the partial derivatives to the function values at the finite-difference grid points.

With the functions and the partial derivatives evaluated at $(m + \theta, n)$, the difference quotients are

$$W = \theta W_{m+1}^n + (1 - \theta) W_m^n \quad (43a)$$

$$\frac{\partial W}{\partial \eta} = \theta (a_1 W_{m+1}^{n+1} + b_1 W_{m+1}^n + c_1 W_{m+1}^{n-1}) + (1 - \theta) (a_1 W_m^{n+1} + b_1 W_m^n + c_1 W_m^{n-1}) \quad (43b)$$

$$\frac{\partial^2 W}{\partial \eta^2} = \theta (a_2 W_{m+1}^{n+1} + b_2 W_{m+1}^n + c_2 W_{m+1}^{n-1}) + (1 - \theta) (a_2 W_m^{n+1} + b_2 W_m^n + c_2 W_m^{n-1}) \quad (43c)$$

and

$$\frac{\partial W}{\partial \xi} = \frac{W_{m+1}^n - W_m^n}{\Delta \xi} \quad (43d)$$

where

$$a_1 = \Delta \eta_{n-1} / (\Delta \eta_n \Delta \eta_T) \quad (44a)$$

$$b_1 = (\Delta \eta_n - \Delta \eta_{n-1}) / (\Delta \eta_n \Delta \eta_{n-1}) \quad (44b)$$

$$c_1 = -\Delta \eta_n / (\Delta \eta_{n-1} \Delta \eta_T) \quad (44c)$$

$$a_2 = 2 / (\Delta \eta_n \Delta \eta_T) \quad (44d)$$

$$b_2 = -2 / (\Delta \eta_n \Delta \eta_{n-1}) \quad (44e)$$

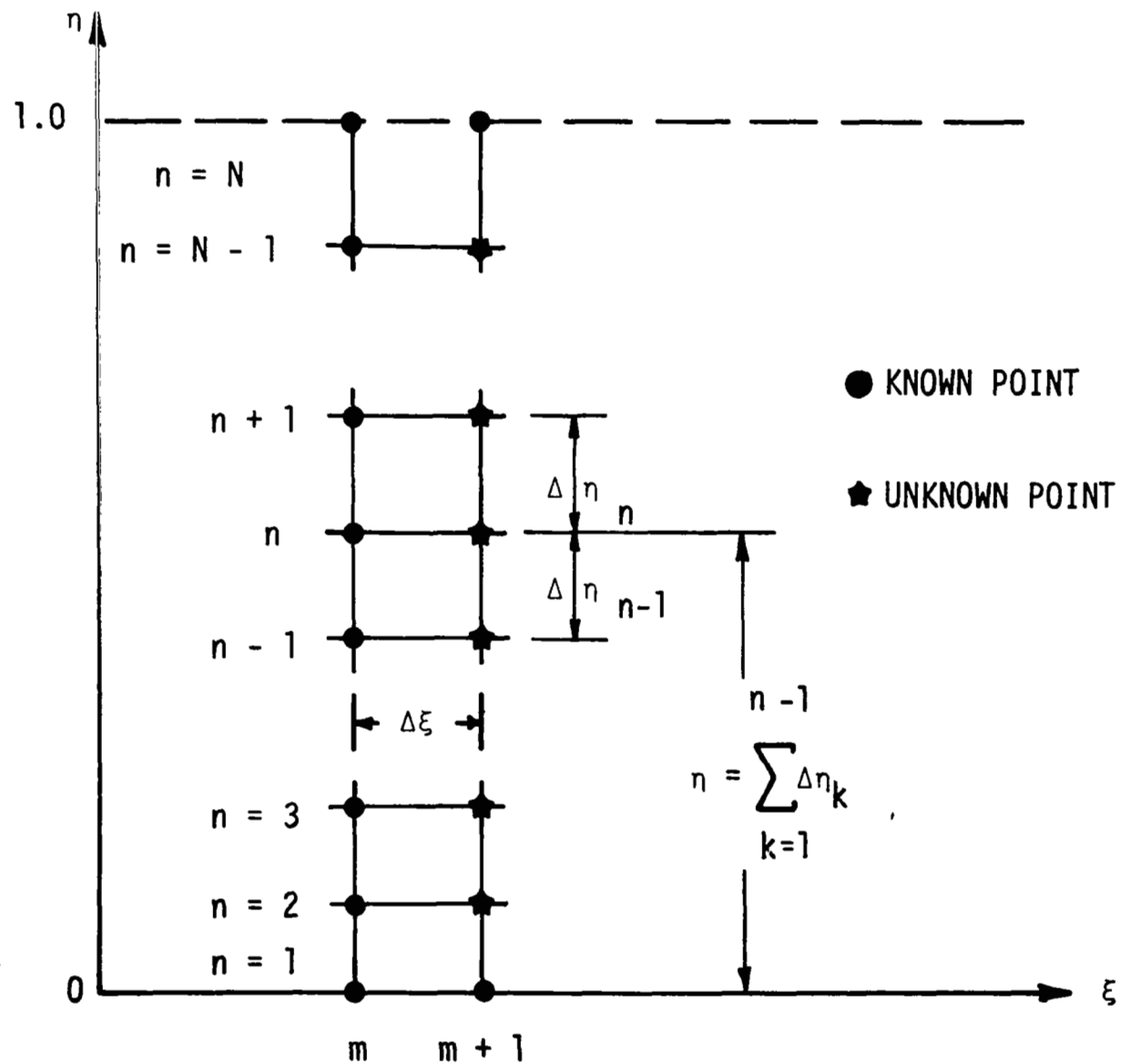


Figure 4. Schematic of Finite-Difference Grid System

$$c_2 = 2/(\Delta\eta_{n-1} \Delta\eta_T) \quad (44f)$$

$$\Delta\eta_T = \Delta\eta_n + \Delta\eta_{n-1} \quad (44g)$$

$$\Delta\eta_n = \eta_{n+1} - \eta_n \quad (44h)$$

$$\Delta\eta_{n-1} = \eta_n - \eta_{n-1} \quad (44i)$$

Substitution of Eqs. (43) into Eq. (15) gives the following simultaneous linear algebraic equations involving only W at $m+1$.

$$\tilde{A}_n W_{m+1}^{n-1} + \tilde{B}_n W_{m+1}^n + \tilde{C}_n W_{m+1}^{n+1} = \tilde{D}_n \quad (45)$$

where $n = 2, 3, \dots, N-1$. The coefficients for Eq. (45) are given by the following expressions:

$$\tilde{A}_n = (c_2 + A_{1n} c_1) \theta \quad (46a)$$

$$\tilde{B}_n = (b_2 + A_{1n} b_1 + A_{2n}) \theta + A_{4n} / \Delta\xi \quad (46b)$$

$$\tilde{C}_n = (a_2 + A_{1n} a_1) \theta \quad (46c)$$

and

$$\tilde{D}_n = - \left[\left(\frac{\partial^2 W}{\partial \eta^2} \right)_m^n + A_{1n} \left(\frac{\partial W}{\partial \eta} \right)_m^n + A_{2n} W_m^n \right] (1 - \theta) - A_{3n} + A_{4n} W_m^n / \Delta\xi \quad (46d)$$

where A_{1n} , A_{2n} , A_{3n} and A_{4n} are the coefficients of Eq. (15) evaluated at the n^{th} grid point and are given by Eqs. (16), (17) and (18) for the s -momentum, energy and species conservation equations.

Assuming that

$$W_{m+1}^n = \tilde{E}_n W_{m+1}^{n+1} + \tilde{F}_n \quad (47)$$

is valid through the shock layer then w_{m+1}^{n-1} is given by

$$w_{m+1}^{n-1} = \tilde{E}_{n-1} w_{m+1}^n + \tilde{F}_{n-1} \quad (48)$$

Substituting Eq. (48) into Eq. (45) and solving for w_{m+1}^n and comparing with Eq. (47) gives the recursion formulas

$$\tilde{E}_n = \frac{-\tilde{C}_n}{\tilde{B}_n + \tilde{A}_n \tilde{E}_{n-1}} \quad (49a)$$

and

$$\tilde{F}_n = \frac{\tilde{D}_n - \tilde{A}_n \tilde{F}_{n-1}}{\tilde{B}_n + \tilde{A}_n \tilde{E}_{n-1}} \quad (49b)$$

At $n = 1$,

$$\tilde{F}_1 = w_w \text{ and } \tilde{E}_1 = 0, \text{ if } w_{m+1}^1 = w_w \quad (50a)$$

or

$$\tilde{F}_1 = 0 \text{ and } \tilde{E}_1 = 1, \text{ if } \left(\frac{\partial w}{\partial \eta} \right)^1_{m+1} = 0 \quad (50b)$$

For $n = N$, the value of w is

$$w_{m+1}^N = w_{sh} \quad (51)$$

The solution of Eq. (15) is provided by the following algorithm. Starting with Eqs. (50), the \tilde{E}_n and \tilde{F}_n are evaluated with n increasing from 2 to $N - 1$. Then the w_{m+1}^n are evaluated from Eq. (47) with n decreasing from $N - 1$ to 1.

Solution for Y-Momentum and Continuity Equations

The normal momentum equation, Eq. (20a), is rewritten so that $\partial \bar{P} / \partial \eta$ may be evaluated directly as

$$\frac{\partial \bar{P}}{\partial \eta} = \frac{\kappa y_{sh} \rho_{sh} u_{sh}^2}{P_{sh} (1 + \kappa y_{sh} \eta)} \quad \bar{\rho} \bar{u} - \frac{\rho_{sh} v_{sh}^2}{P_{sh}} \quad \bar{\rho} \bar{v} \frac{\partial \bar{v}}{\partial \eta} -$$

$$\frac{y_{sh} \rho_{sh} u_{sh} v_{sh}}{P_{sh} (1 - \kappa y_{sh} \eta)} \quad \bar{\rho} \bar{u} \left(\frac{\partial \bar{v}}{\partial \xi} + \frac{\bar{v}}{v_{sh}} \frac{\partial v_{sh}}{\partial \xi} - \frac{y'_{sh}}{y_{sh}} \frac{\partial \bar{v}}{\partial \xi} \right) \quad (52)$$

with only the first term on the right side of the equation retained when the thin shock-layer approximation is made, Eq. (20b). With the y-momentum equation written in this form, Eq. (52) or (20b), the pressure derivative with respect to η is calculated. With \bar{P} at the shock known, $\bar{P}_{sh} = 1$, integration by the trapezoidal rule from the shock inward gives the solution of the normal momentum equation.

The continuity equation, Eq. (19), when integrated yields both the normal velocity (v) profile and the shock-layer thickness, y_{sh} . As given previously, the continuity equation is

$$\frac{\partial}{\partial \xi} \{ y_{sh} (r + y_{sh} \eta \cos \phi)^j \rho_{sh} u_{sh} \bar{\rho} \bar{u} \} =$$

$$\frac{\partial}{\partial \eta} \{ (r + y_{sh} \eta \cos \phi)^j \{ y'_{sh} \rho_{sh} u_{sh} \bar{\rho} \bar{u} \eta - (1 + \kappa y_{sh} \eta) \rho_{sh} v_{sh} \bar{\rho} \bar{v} \} \} \quad (19)$$

where $j = 1$ for axisymmetric flow and $j = 0$ for two-dimensional flow.

The mass flux between the body ($\eta = 0$) and a given grid point n ($\eta = \eta_n$) is proportional to m_n (with m_N denoting $\eta = 1$, the shock) which is given by

$$m_n = \int_0^{\eta_n} y_{sh} (r + y_{sh} \eta \cos \phi)^j \rho_{sh} u_{sh} \bar{\rho} \bar{u} d\eta \quad (53)$$

Integrating Eq. (19) from 0 to η and substituting Eq. (53) gives the following form for the continuity equation.

$$\frac{dm_n}{d\xi} = \int_0^{\eta_n} \frac{\partial}{\partial \eta} \{ (r + y_{sh} \eta \cos \phi)^j \{ y'_{sh} \rho_{sh} u_{sh} \bar{\rho} \bar{u} \eta -$$

$$(1 + \kappa y_{sh} \eta) \rho_{sh} v_{sh} \bar{\rho} \bar{v} \} \} d\eta \quad (54)$$

or equivalently as

$$\frac{dm_n}{d\xi} = (r + y_{sh} \eta \cos \phi)^j \{y'_{sh} \rho_{sh} u_{sh} \bar{\rho} \bar{u} \eta - (1 + \kappa y_{sh} \eta) \rho_{sh} v_{sh} \bar{\rho} \bar{v}\} \quad (55)$$

The term $dm_n/d\xi$ is obtained by evaluating Eq. (53) as $s + ds/2$ and $s - ds/2$ and dividing by ds . The normal velocity, v , is then obtained by rearranging Eq. (55).

The shock-layer thickness is obtained by integrating Eqs. (53) and (54) from 0 to 1 instead of from 0 to η . This gives

$$m_N = y_{sh} \rho_{sh} u_{sh} r^j \int_0^1 \bar{\rho} \bar{u} d\eta + j y_{sh}^2 \rho_{sh} u_{sh} \cos \phi \int_0^1 \bar{\rho} \bar{u} \eta d\eta \quad (56)$$

and

$$\frac{dm_N}{d\xi} = (r + y_{sh} \cos \phi)^j \{y'_{sh} \rho_{sh} u_{sh} - (1 + \kappa y_{sh}) \rho_{sh} v_{sh}\} \quad (57)$$

The term $dm_N/d\xi$ could also be evaluated from

$$\frac{dm_N}{d\xi} = \frac{1}{\Delta\xi} \left[(m_N)_{s + ds/2} - (m_N)_{s - ds/2} \right] \quad (58)$$

Rearranging Eq. (58) gives

$$(m_N)_{s + ds/2} = \Delta\xi \frac{dm_N}{d\xi} + (m_N)_{s - ds/2} \quad (59)$$

First, $dm_N/d\xi$ is evaluated from Eq. (57). Eq. (59) then gives m_N and Eq. (56) is solved for y_{sh} .

When written as in Eq. (19), the continuity equation is indeterminate at $s = 0$. In order to evaluate the continuity equation at the stagnation point the following limit expressions as $\xi \rightarrow 0$ are used:

$r \rightarrow \xi$, $\cos \phi \rightarrow \xi$ and $u_{sh} \rightarrow \xi u'_{sh}$ where $u'_{sh} = d u_{sh}/d\xi$. Also, at $s = 0$, $y'_{sh} = 0$.

Denoting $r|_{\Delta\xi/2}$ as r_2 and $\cos \phi|_{\Delta\xi/2}$ as $\cos \phi_2$, the form of the continuity equation is

$$\frac{\partial}{\partial \eta} \left[(1 + y_{sh} \eta)^{j+1} \bar{\rho} \bar{v} \right] = \left(\frac{2}{\Delta\xi} \right)^{j+1} (j+1) y_{sh} (r_2 + y_{sh} \eta \cos \phi_2)^j \rho_{sh} u_{sh} \bar{\rho} \bar{u} \quad (60)$$

where $\rho_{sh} v_{sh} = -\sin \alpha = -1$ at $s = 0$ has been used. Integrating from 0 to η and rearranging terms gives the following expression for the normal velocity component.

$$\bar{v} = \left(\frac{2}{\Delta\xi} \right)^{j+1} \frac{(j+1) y_{sh} \rho_{sh} u_{sh}}{\bar{\rho} (1 + y_{sh} \eta)^{j+1}} \left[r_2^j \int_0^\eta \bar{\rho} \bar{u} d\eta + j y_{sh} \cos \phi_2 \int_0^\eta \bar{\rho} \bar{u} \eta d\eta \right] \quad (61)$$

Integrating Eq. (60) from 0 to 1 gives the following equation

$$(1 + y_{sh})^{j+1} = \left(\frac{2}{\Delta\xi} \right)^{j+1} (j+1) y_{sh} \rho_{sh} u_{sh} \left[r_2^j \int_0^1 \bar{\rho} \bar{u} d\eta + j y_{sh} \cos \phi_2 \int_0^1 \bar{\rho} \bar{u} \eta d\eta \right] \quad (62)$$

which can be solved for the shock-layer thickness, y_{sh} , by rearranging terms.

An alternate method for determining the shock-layer thickness, y_{sh} , is given in the companion engineering report.

Solution Procedure

At each s or ξ location the shock-layer equations are solved in the order of species, energy, s -momentum, continuity and y -momentum. At each location the solution is iterated until convergence is obtained for the tangential velocity, temperature and species concentration profiles at all points of the finite-difference grid. The convergence test requires that

$$\left| 1 - w_n^{k+1}/w_n^k \right| \leq \delta$$

where n denotes the finite-difference grid point, k denotes the previous iteration value of W_n , $k + 1$ denotes the new iteration value of W_n , W represents \bar{u} , \bar{T} or C_i and δ is a small number, typically 0.01. After a converged solution is obtained at a specific location, ξ , the profiles are then used as initial profiles for obtaining a new solution at $\xi + \Delta\xi$. In this way the solution procedure marches downstream.

If the governing equations were fully parabolic, only one global iteration (i.e., a solution for the entire length of the body) would be sufficient. However, the equations depend upon $d y_{sh}/d\xi$ (and thus the shock angle). Also, the y -momentum equation (in FVSL form) depends upon $\partial \bar{v}/\partial \xi$ which is not known (especially at the stagnation point). The downstream dependence introduces an elliptic nature to the equations. The elliptic effect in the y -momentum equation is resolved by considering TVSL flows for the first global iteration. Subsequent global iterations may then be FVSL using the \bar{v} profiles from the previous global iteration.

The elliptic effect due to $d y_{sh}/d\xi$ is resolved by making a suitable approximation for $d y_{sh}/d\xi$ for the first global iteration. Subsequent global iterations then use $d y_{sh}/d\xi$ as calculated from the previous global iteration.

List of Symbols

C_i	concentration of species i , ρ_i/ρ
C_p	specific heat at constant pressure
ECW	denotes equilibrium catalytic wall
FVSL	denotes fully viscous shock layer
h	static enthalpy, h^*/U_∞^{*2}
H	total enthalpy, H^*/U_∞^{*2}
k	thermal conductivity, $k^*/(\mu_{ref}^* C_{p\infty}^*)$
Le_i	Lewis number, $C_p^* \rho^* D_i^*/k^*$
M	Molecular weight
\bar{M}	mixture molecular weight, $1/(\sum_i C_i/M_i)$
n_j	number of species plus catalytic third bodies, $n_s + n_z$
n_s	number of species
n_r	number of chemical reaction
n_z	number of catalytic third bodies
NSS	denotes no shock slip
NCW	denotes noncatalytic wall
P	pressure, $P^*/(\rho_\infty^* U_\infty^{*2})$
Pr	Prandtl number, $C_p^* \mu^*/k^*$
q	heat transfer, $q^*/(\rho_\infty^* U_\infty^{*3})$
r	body radius, r^*/R_n^*
R	universal gas constant
R_n^*	body nose radius
Re_s	shock Reynolds number, $\frac{\rho_\infty^* U_\infty^* R_n^*}{\mu_{sh}^*}$

s	coordinate measured along body surface, s^*/R_n^*
St	Stanton number, $q_w/(H_\infty - H_w)$
SS	denotes shock slip
T	temperature, T^*/T_{ref}^*
T_{ref}^*	reference temperature, $U_\infty^{*2}/C_{p\infty}^*$
TVSL	denotes thin viscous shock layer
u	velocity component tangent to the body surface, u^*/U_∞^*
v	velocity component normal to the body surface, v^*/U_∞^*
y	coordinate measured normal to the body, y^*/R_n^*
z	coordinate measured along body axis, z^*/R_n^*
$Z(j\text{-ns}), i$	third body catalytic efficiencies relative to argon
α	angle between shock tangent and body axis
α_{rj}	forward stoichiometric coefficients
β_{rj}	backward stoichiometric coefficients
γ_i	species mass concentrations, C_i/M_i
ϵ	Reynolds number parameter, $\left[\frac{\mu_{ref}^*}{\rho_\infty^* U_\infty^* R_n^*} \right]^{1/2}$
κ	surface curvature, κ^*/R_n^*
μ	coefficient of viscosity, μ^*/μ_{ref}^*
μ_{ref}^*	coefficient of viscosity evaluated at T_{ref}^*
ρ	density, ρ^*/ρ_∞^*
ϕ	angle between body tangent and axis

Superscripts

j	indicator for axisymmetric flow (1) or two-dimensional flow (0)
*	dimensional quantities
'	denotes differentiation with respect to ξ

Subscripts

eq	equilibrium value
i	specie i
sh	value behind the shock
w	wall value
∞	freestream value

APPENDIX B: SAMPLE CASES

Input and output data are given for four sample cases; two geometries and two gas chemistries for each geometry. The geometries are a 31° hyperboloid and a curve fit geometry (the 140B orbiter). The gas chemistries are binary gas (dissociating oxygen) and 7-species (multicomponent) air. The Job Control Language (JCL) needed to run the sample cases on the IBM 370/158 computers of the Virginia Polytechnic Institute and State University Computing Center is also listed. The sample cases were run in double precision with the source program and all input data from cards.

Job Control Language for the 140B Orbiter Sample Cases

```
//BO030VSL JOB 509E3,MINER,MSGLEVEL=(1,1)
/*PRIORITY IDLE
/*MAIN TIME=05,LINES=10,CARDS=0
/*MAIN REGION=238K
// EXEC FORTGCLG
//FORT.SYSIN DD *
```

FORTRAN Source Program

```
/*
//GO.FT01F001 DD SYSOUT=A
//GO.FT03F001 DD SYSOUT=A
//GO.FT08F001 DD SYSOUT=A
//GO.FT09F001 DD SYSOUT=A
//GO.FT15F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(440,(200)),
//   DCB=(RECFM=VS,BLKSIZE=440,LRECL=436)
//GO.FT16F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(440,(200)),
//   DCB=(RECFM=VS,BLKSIZE=440,LRECL=436)
//GO.FT04F001 DD *
```

Body Geometry Data

```
/*
//GO.FT19F001 DD *
```

Reaction Rate Data

```
/*
//GO.FT20F001 DD *
```

Shock Shape Data

```
/*
//GO.SYSIN DD *
```

Unit 5 Input Data

```
/*
//
```

Job Control Language for the 31° Hyperboloid Sample Cases

```
//B0030VSL JOB 509E3,MINER,MSGLEVEL=(1,1)
/*PRIORITY IDLE
/*MAIN TIME=05,LINES=10,CARDS=0
/*MAIN REGION=238K
// EXEC FORTGCLG
//FORT.SYSIN DD *
```

FORTRAN Source Program

```
/*
//GO.FT01F001 DD SYSOUT=A
//GO.FT03F001 DD SYSOUT=A
//GO.FT08F001 DD SYSOUT=A
//GO.FT09F001 DD SYSOUT=A
//GO.FT15F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(440,(200)),
//   DCB=(RECFM=VS,BLKSIZE=440,LRECL=436)
//GO.FT16F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(440,(200)),
//   DCB=(RECFM=VS,BLKSIZE=440,LRECL=436)
//GO.FT19F001 DD *
```

Reaction Rate Data

```
/*
//GO.FT20F001 DD *
```

Shock Shape Data

```
/*
//GO.SYSIN DD *
```

Unit 5 Input Data

```
/*
//
```

Reaction Rate Input Data for all Sample Cases

The same reaction rate data are used for all of the sample cases.

LOG RATES MATCH 6 SPECIE BLOTTNER-SANDIA

2	2											
0	02											
02	02			0	0	02		3.249E1959400.-1.		2.709E16		-.5
02	0			0	0	0		9.025E1959400.-1.		7.525E16		-.5
10	7	4										
0	02	NO	N	NO+	N2	M1	M2	M3	EL			
02	M1			C	C	M1		3.61E1859400.-1.		3.01E15		-.5
N2	M2			N	N	M2		1.92E17113100-.5		1.09E16		-.5
N2	N			N	N	N		4.15E22113100-1.5		2.32E21		-1.5
NO	M3			N	O	M3		3.97E2075600.-1.5		1.01E20		-1.5
NO	0			02	N			3.18E919700. 1.		9.63E113600. .5		
N2	0			NO	N			6.75E1337500.		1.50E13		
N	0			NO+	EL			9.03E932400..5		1.80E19		-1.
25.		9.			1.		1.			2.		
1.		1.			1.					2.5		
20.		1.			20.		20.			1.		
								1.				
				.23456						.76544		
				.23456						.76544		

Body Geometry Input Data for the 140B Orbiter Sample Cases

0.0	0.0	0.0	1.000000E 00	1.570800E 00
2.922039E-06	2.418570E-03	2.418570E-03	9.973460E-01	1.569590E 00
6.723169E-06	3.669430E-03	3.669430E-03	9.959680E-01	1.567760E 00
1.222290E-05	4.948780E-03	4.948799E-03	9.945550E-01	1.566500E 00
1.953149E-05	6.257229E-03	6.257258E-03	9.931059E-01	1.565209E 00
2.876460E-05	7.595357E-03	7.595427E-03	9.916199E-01	1.563900E 00
4.004329E-05	8.963808E-03	8.963928E-03	9.900970E-01	1.562550E 00
5.349469E-05	1.036320E-02	1.036340E-02	9.885350E-01	1.561179E 00
6.925169E-05	1.179420E-02	1.179440E-02	9.869339E-01	1.559790E 00
8.745359E-05	1.325730E-02	1.325770E-02	9.852920E-01	1.558359E 00
1.168470E-04	1.473850E-02	1.473920E-02	1.013370E 00	1.550949E 00
1.505300E-04	1.625050E-02	1.625160E-02	1.011570E 00	1.548519E 00
1.873590E-04	1.779640E-02	1.779790E-02	1.009729E 00	1.546980E 00
2.275070E-04	1.937670E-02	1.937870E-02	1.007850E 00	1.545400E 00
2.711518E-04	2.099220E-02	2.099480E-02	1.005910E 00	1.543790E 00
3.184839E-04	2.264370E-02	2.264690E-02	1.003929E 00	1.542139E 00
3.696978E-04	2.433170E-02	2.433570E-02	1.001900E 00	1.540469E 00
4.250000E-04	2.605710E-02	2.606200E-02	9.998159E-01	1.538759E 00
4.846030E-04	2.782050E-02	2.782640E-02	9.976820E-01	1.537009E 00
5.487299E-04	2.962280E-02	2.962990E-02	9.954939E-01	1.535230E 00
6.176129E-04	3.146470E-02	3.147300E-02	9.932520E-01	1.533420E 00
6.914949E-04	3.334690E-02	3.335670E-02	9.909550E-01	1.531560E 00
7.706280E-04	3.527030E-02	3.528170E-02	9.886020E-01	1.529679E 00
8.646848E-04	3.721940E-02	3.723310E-02	1.014429E 00	1.522579E 00
9.681918E-04	3.920490E-02	3.922130E-02	1.011849E 00	1.518709E 00
1.078080E-03	4.123340E-02	4.125280E-02	1.009219E 00	1.516680E 00
1.194660E-03	4.330590E-02	4.332860E-02	1.006510E 00	1.514609E 00
1.318240E-03	4.542310E-02	4.544930E-02	1.003750E 00	1.512489E 00
1.449140E-03	4.758590E-02	4.761610E-02	1.000910E 00	1.510340E 00
1.587720E-03	4.979510E-02	4.982960E-02	9.980110E-01	1.508149E 00
1.734330E-03	5.205160E-02	5.209090E-02	9.950390E-01	1.505919E 00
1.889340E-03	5.435640E-02	5.440090E-02	9.919960E-01	1.503639E 00
2.053130E-03	5.671030E-02	5.676050E-02	9.888800E-01	1.501329E 00
2.229920E-03	5.910760E-02	5.916430E-02	1.012190E 00	1.497180E 00
2.428080E-03	6.153550E-02	6.160030E-02	1.008789E 00	1.489360E 00
2.636620E-03	6.401455E-02	6.408817E-02	1.005309E 00	1.486879E 00
2.856000E-03	6.654596E-02	6.662905E-02	1.001750E 00	1.484349E 00
3.086700E-03	6.913060E-02	6.922400E-02	9.981010E-01	1.481779E 00
3.329190E-03	7.176936E-02	7.187378E-02	9.943710E-01	1.479159E 00
3.583980E-03	7.446319E-02	7.457978E-02	9.905550E-01	1.476500E 00
3.851610E-03	7.721329E-02	7.734287E-02	9.866530E-01	1.473789E 00
4.132599E-03	8.002067E-02	8.016419E-02	9.826620E-01	1.471029E 00
4.435159E-03	8.287299E-02	8.303237E-02	1.003059E 00	1.465110E 00
4.762709E-03	8.576638E-02	8.594429E-02	9.987150E-01	1.458070E 00
5.105790E-03	8.871937E-02	8.891720E-02	9.942740E-01	1.455130E 00
5.465649E-03	9.173298E-02	9.195209E-02	9.897360E-01	1.452149E 00
5.841140E-03	9.480846E-02	9.505045E-02	9.850990E-01	1.449109E 00
6.234739E-03	9.794658E-02	9.821337E-02	9.803620E-01	1.446030E 00
6.646547E-03	1.011490E-01	1.014420E-01	9.755239E-01	1.442900E 00
7.077307E-03	1.044160E-01	1.047380E-01	9.705840E-01	1.439710E 00
7.542837E-03	1.077240E-01	1.080779E-01	9.677980E-01	1.430960E 00
8.034170E-03	1.110890E-01	1.114790E-01	9.624430E-01	1.425830E 00
8.547239E-03	1.145220E-01	1.149499E-01	9.576970E-01	1.422460E 00
9.082880E-03	1.180249E-01	1.184930E-01	9.514040E-01	1.419029E 00
9.641968E-03	1.215970E-01	1.221090E-01	9.4657180E-01	1.415549E 00
1.022540E-02	1.252410E-01	1.257989E-01	9.399200E-01	1.412029E 00
1.083410E-02	1.289570E-01	1.295649E-01	9.340100E-01	1.408449E 00
1.148910E-02	1.327130E-01	1.333770E-01	9.279510E-01	1.398109E 00
1.217370E-02	1.365390E-01	1.372640E-01	9.215780E-01	1.393769E 00
1.288700E-02	1.404409E-01	1.412309E-01	9.1550860E-01	1.389990E 00
1.363000E-02	1.444200E-01	1.452790E-01	9.084770E-01	1.386169E 00
1.440400E-02	1.484770E-01	1.494090E-01	9.017490E-01	1.382290E 00
1.521000E-02	1.526130E-01	1.536230E-01	8.949020E-01	1.378360E 00
1.606600E-02	1.568020E-01	1.578979E-01	8.876690E-01	1.369200E 00
1.696350E-02	1.610600E-01	1.622500E-01	8.803820E-01	1.363050E 00
1.789720E-02	1.654000E-01	1.666890E-01	8.7308670E-01	1.358919E 00
1.886830E-02	1.698250E-01	1.712199E-01	8.6523849E-01	1.354750E 00
1.987820E-02	1.743349E-01	1.758420E-01	8.575830E-01	1.350519E 00
2.092860E-02	1.789320E-01	1.805570E-01	8.50234329E-01	1.346149E 00
2.204520E-02	1.835750E-01	1.853319E-01	8.4252240E-01	1.334749E 00
2.320530E-02	1.883060E-01	1.902030E-01	8.348960E-01	1.330339E 00
2.441050E-02	1.931280E-01	1.951730E-01	8.2748480E-01	1.325870E 00
2.566230E-02	1.980420E-01	2.002439E-01	8.2038840E-01	1.321360E 00
2.696220E-02	2.030489E-01	2.054180E-01	8.132050E-01	1.316810E 00
2.833080E-02	2.081190E-01	2.106690E-01	8.057329E-01	1.307159E 00

2.975870E-02	2.132730E-01	2.160169E-01	8.765520E-01	1.300489E 00
3.124040E-02	2.185240E-01	2.214730E-01	8.672619E-01	1.295759E 00
3.277780E-02	2.238740E-01	2.270390E-01	8.578629E-01	1.290979E 00
3.437260E-02	2.293240E-01	2.327180E-01	8.483599E-01	1.286160E 00
3.604730E-02	2.348419E-01	2.384850E-01	8.500270E-01	1.276099E 00
3.779050E-02	2.404510E-01	2.443590E-01	8.400480E-01	1.269500E 00
3.959760E-02	2.461660E-01	2.503520E-01	8.299720E-01	1.264520E 00
4.147070E-02	2.519870E-01	2.564670E-01	8.198040E-01	1.259489E 00
4.341410E-02	2.579130E-01	2.627040E-01	8.191280E-01	1.253920E 00
4.545380E-02	2.639050E-01	2.690340E-01	8.085200E-01	1.242680E 00
4.756670E-02	2.700080E-01	2.754920E-01	7.978320E-01	1.237510E 00
4.975510E-02	2.762250E-01	2.820820E-01	7.870700E-01	1.232309E 00
5.202140E-02	2.825560E-01	2.888070E-01	7.762380E-01	1.227070E 00
5.274590E-02	2.918150E-01	2.980940E-01	6.544350E-01	1.492709E 00
5.478100E-02	2.990659E-01	3.056250E-01	6.464400E-01	1.297179E 00
5.689330E-02	3.064530E-01	3.133079E-01	6.383880E-01	1.292259E 00
5.908550E-02	3.139780E-01	3.211460E-01	6.302820E-01	1.287310E 00
6.158730E-02	3.212489E-01	3.288360E-01	5.711100E-01	1.239440E 00
6.374609E-02	3.294050E-01	3.372729E-01	5.640219E-01	1.312030E 00
6.598818E-02	3.377140E-01	3.458790E-01	5.568939E-01	1.307230E 00
6.831628E-02	3.461780E-01	3.546570E-01	5.497280E-01	1.302389E 00
7.147789E-02	3.535120E-01	3.626429E-01	5.528400E-01	1.163759E 00
7.403809E-02	3.622070E-01	3.717080E-01	5.453650E-01	1.284439E 00
7.669437E-02	3.710639E-01	3.809550E-01	5.378600E-01	1.279440E 00
7.940406E-02	3.801650E-01	3.904510E-01	5.421460E-01	1.281420E 00
8.232319E-02	3.892490E-01	3.999910E-01	5.342979E-01	1.259850E 00
8.534908E-02	3.985000E-01	4.097250E-01	5.264300E-01	1.254700E 00
8.848506E-02	4.079240E-01	4.196570E-01	5.185460E-01	1.249530E 00
9.173477E-02	4.175220E-01	4.257900E-01	5.106490E-01	1.244329E 00
9.510165E-02	4.272970E-01	4.401290E-01	5.027420E-01	1.239100E 00
9.858948E-02	4.372530E-01	4.506789E-01	4.948300E-01	1.233850E 00
1.022020E-01	4.473940E-01	4.614429E-01	4.869159E-01	1.228580E 00
1.059430E-01	4.577219E-01	4.724280E-01	4.790030E-01	1.223280E 00
1.098160E-01	4.682400E-01	4.836370E-01	4.710950E-01	1.217970E 00
1.138260E-01	4.789529E-01	4.950750E-01	4.631950E-01	1.212629E 00
1.179760E-01	4.898630E-01	5.067490E-01	4.553080E-01	1.207279E 00
1.222720E-01	5.009750E-01	5.186620E-01	4.474360E-01	1.201909E 00
1.267170E-01	5.129220E-01	5.308200E-01	4.395840E-01	1.196529E 00
1.313159E-01	5.238169E-01	5.432290E-01	4.317549E-01	1.191130E 00
1.360739E-01	5.355549E-01	5.558950E-01	4.239520E-01	1.185710E 00
1.409950E-01	5.475100E-01	5.688230E-01	4.161800E-01	1.180289E 00
1.460840E-01	5.596850E-01	5.820180E-01	4.084400E-01	1.174850E 00
1.513470E-01	5.720840E-01	5.954880E-01	4.007379E-01	1.169410E 00
1.567880E-01	5.847120E-01	6.092390E-01	3.930759E-01	1.163960E 00
1.624129E-01	5.975730E-01	6.232760E-01	3.854570E-01	1.158489E 00
1.684440E-01	6.102970E-01	6.373560E-01	3.872679E-01	1.128180E 00
1.745920E-01	6.233950E-01	6.518260E-01	3.793640E-01	1.131940E 00
1.809440E-01	6.367350E-01	6.666009E-01	3.715190E-01	1.126400E 00
1.875049E-01	6.503209E-01	6.816880E-01	3.637379E-01	1.120850E 00
1.942829E-01	6.641560E-01	6.970950E-01	3.560230E-01	1.115299E 00
2.012820E-01	6.782460E-01	7.128280E-01	3.483770E-01	1.109759E 00
2.085130E-01	6.925970E-01	7.288949E-01	3.408030E-01	1.104219E 00
2.159719E-01	7.072110E-01	7.453049E-01	3.333049E-01	1.098689E 00
2.236770E-01	7.220960E-01	7.620650E-01	3.258840E-01	1.093160E 00
2.316300E-01	7.372560E-01	7.791840E-01	3.185440E-01	1.087640E 00
2.398390E-01	7.526950E-01	7.966710E-01	3.112860E-01	1.082129E 00
2.483110E-01	7.684210E-01	8.145330E-01	3.041130E-01	1.076630E 00
2.570540E-01	7.844369E-01	8.327810E-01	2.970279E-01	1.071139E 00
2.660750E-01	8.007510E-01	8.514220E-01	2.900330E-01	1.065660E 00
2.743730E-01	8.191150E-01	8.715740E-01	2.890390E-01	1.146410E 00
2.841840E-01	8.356780E-01	8.908250E-01	2.818840E-01	1.036019E 00
2.943020E-01	8.525470E-01	9.104960E-01	2.748350E-01	1.030530E 00
3.047349E-01	8.697300E-01	9.305980E-01	2.678930E-01	1.025069E 00
3.154939E-01	8.872310E-01	9.511420E-01	2.610590E-01	1.019629E 00
3.265859E-01	9.050580E-01	9.721380E-01	2.543350E-01	1.014199E 00
3.380210E-01	9.232170E-01	9.935970E-01	2.477220E-01	1.008809E 00
3.498090E-01	9.417140E-01	1.015530E 00	2.412210E-01	1.003429E 00
3.619580E-01	9.605570E-01	1.037950E 00	2.348329E-01	9.980820E-01
3.744810E-01	9.797519E-01	1.060869E 00	2.285579E-01	9.927590E-01
3.875329E-01	9.990500E-01	1.084169E 00	2.240019E-01	9.761310E-01
4.009970E-01	1.018680E 00	1.107969E 00	2.178020E-01	9.697180E-01
4.148670E-01	1.038690E 00	1.132319E 00	2.117220E-01	9.644750E-01
4.291570E-01	1.059070E 00	1.157200E 00	2.057640E-01	9.592640E-01
4.438760E-01	1.079829E 00	1.182659E 00	1.999280E-01	9.540850E-01
4.590369E-01	1.100980E 00	1.208679E 00	1.942120E-01	9.489400E-01

4.746520E-01	1.122530E 00	1.235299E 00	1.886179E-01	9.438290E-01
4.907320E-01	1.144489E 00	1.262509E 00	1.831450E-01	9.387529E-01
5.072920E-01	1.166869E 00	1.290350E 00	1.777910E-01	9.337119E-01
5.243430E-01	1.189670E 00	1.318820E 00	1.725570E-01	9.287060E-01
5.418990E-01	1.212910E 00	1.347950E 00	1.674410E-01	9.237379E-01
5.595740E-01	1.236589E 00	1.377729E 00	1.624430E-01	9.188060E-01
5.785810E-01	1.260719E 00	1.408210E 00	1.575609E-01	9.139130E-01
5.977350E-01	1.285310E 00	1.439380E 00	1.527960E-01	9.090570E-01
6.174520E-01	1.310369E 00	1.471270E 00	1.481450E-01	9.042400E-01
6.382710E-01	1.334999E 00	1.503519E 00	1.435710E-01	8.690880E-01
6.593660E-01	1.360680E 00	1.536750E 00	1.390750E-01	8.829800E-01
6.810730E-01	1.386840E 00	1.570740E 00	1.346940E-01	8.783060E-01
7.034079E-01	1.413520E 00	1.605530E 00	1.304269E-01	8.736740E-01
7.263890E-01	1.440709E 00	1.641129E 00	1.262720E-01	8.690839E-01
7.500319E-01	1.468419E 00	1.677569E 00	1.222270E-01	8.645360E-01
7.743559E-01	1.496679E 00	1.714849E 00	1.182910E-01	8.600320E-01
7.993780E-01	1.525479E 00	1.752999E 00	1.144630E-01	8.555710E-01
8.251160E-01	1.554850E 00	1.792049E 00	1.107390E-01	8.511530E-01
8.515910E-01	1.584789E 00	1.832020E 00	1.071180E-01	8.467780E-01
8.788210E-01	1.615319E 00	1.872930E 00	1.035990E-01	8.424470E-01
9.070800E-01	1.646009E 00	1.914650E 00	9.962797E-02	8.265700E-01
9.361240E-01	1.677329E 00	1.957359E 00	9.627569E-02	8.230830E-01
9.659890E-01	1.709270E 00	2.001080E 00	9.302217E-02	8.189220E-01
9.966969E-01	1.741830E 00	2.045850E 00	8.986509E-02	8.148070E-01
1.028270E 00	1.775049E 00	2.091669E 00	8.680248E-02	8.107370E-01
1.060730E 00	1.808920E 00	2.138590E 00	8.383238E-02	8.067120E-01
1.094100E 00	1.843470E 00	2.186629E 00	8.095247E-02	8.027329E-01
1.128409E 00	1.878710E 00	2.235809E 00	7.816088E-02	7.987980E-01
1.163670E 00	1.914660E 00	2.286160E 00	7.545537E-02	7.949089E-01
1.199929E 00	1.951320E 00	2.337720E 00	7.283396E-02	7.910640E-01
1.237189E 00	1.988720E 00	2.390510E 00	7.029456E-02	7.872640E-01
1.275479E 00	2.026870E 00	2.444570E 00	6.783527E-02	7.835090E-01
1.314850E 00	2.065800E 00	2.499929E 00	6.545389E-02	7.797980E-01
1.355300E 00	2.105510E 00	2.556620E 00	6.314880E-02	7.761320E-01
1.396870E 00	2.146020E 00	2.614659E 00	6.091760E-02	7.725100E-01
1.440499E 00	2.185789E 00	2.673699E 00	5.786620E-02	7.392580E-01
1.484759E 00	2.227340E 00	2.734409E 00	5.577590E-02	7.537200E-01
1.530239E 00	2.269739E 00	2.796590E 00	5.375530E-02	7.502930E-01
1.576969E 00	2.313000E 00	2.860270E 00	5.180250E-02	7.469110E-01
1.624980E 00	2.357149E 00	2.925489E 00	4.991550E-02	7.435720E-01
1.674299E 00	2.402209E 00	2.992299E 00	4.809250E-02	7.402779E-01
1.724970E 00	2.448199E 00	3.060730E 00	4.633160E-02	7.370260E-01
1.777620E 00	2.495139E 00	3.130819E 00	4.463090E-02	7.338180E-01
1.830489E 00	2.543059E 00	3.202609E 00	4.298870E-02	7.306520E-01
1.885420E 00	2.591960E 00	3.276159E 00	4.140320E-02	7.275280E-01
1.941830E 00	2.641890E 00	3.351489E 00	3.987260E-02	7.244460E-01
1.999769E 00	2.692849E 00	3.428659E 00	3.839540E-02	7.214070E-01
2.061090E 00	2.741770E 00	3.507090E 00	3.610550E-02	6.733590E-01
2.122649E 00	2.794129E 00	3.587910E 00	3.474170E-02	7.048550E-01
2.185869E 00	2.847600E 00	3.670699E 00	3.342680E-02	7.020130E-01
2.250790E 00	2.902189E 00	3.755529E 00	3.215930E-02	6.992120E-01
2.317450E 00	2.957939E 00	3.842429E 00	3.093750E-02	6.964509E-01
2.385900E 00	3.014870E 00	3.931459E 00	2.976000E-02	6.937300E-01
2.456189E 00	3.073000E 00	4.022679E 00	2.862500E-02	6.910480E-01
2.528359E 00	3.132370E 00	4.116130E 00	2.753220E-02	6.884050E-01
2.603330E 00	3.191520E 00	4.211619E 00	2.537840E-02	6.679699E-01
2.680070E 00	3.252310E 00	4.309520E 00	2.438620E-02	6.698890E-01
2.758860E 00	3.314400E 00	4.409840E 00	2.343140E-02	6.674719E-01
2.839740E 00	3.377830E 00	4.512620E 00	2.251270E-02	6.650929E-01
2.922759E 00	3.442639E 00	4.617940E 00	2.162880E-02	6.627510E-01
3.007990E 00	3.508840E 00	4.725860E 00	2.077840E-02	6.604450E-01
3.095469E 00	3.576480E 00	4.836450E 00	1.996050E-02	6.581750E-01
3.185269E 00	3.645590E 00	4.949759E 00	1.917370E-02	6.559409E-01
3.278589E 00	3.714230E 00	5.065599E 00	1.746840E-02	6.341460E-01
3.373879E 00	3.785199E 00	5.184420E 00	1.676550E-02	6.401320E-01
3.471680E 00	3.857730E 00	5.306170E 00	1.609010E-02	6.381159E-01
3.572049E 00	3.931849E 00	5.430949E 00	1.544130E-02	6.361319E-01
3.675050E 00	4.007609E 00	5.558809E 00	1.481800E-02	6.341820E-01
3.780749E 00	4.085050E 00	5.689850E 00	1.421930E-02	6.322640E-01
3.889640E 00	4.163489E 00	5.824039E 00	1.293700E-02	6.242540E-01
4.001550E 00	4.243360E 00	5.961539E 00	1.240560E-02	6.199009E-01
4.116380E 00	4.325029E 00	6.102440E 00	1.189560E-02	6.181740E-01
4.234220E 00	4.408520E 00	6.246849E 00	1.140620E-02	6.164780E-01
4.355100E 00	4.493879E 00	6.394839E 00	1.093650E-02	6.148100E-01
4.479309E 00	4.580870E 00	6.546479E 00	9.965908E-03	6.109580E-01

4.607080E 00	4.669240E 00	6.701839E 00	9.550169E-03	6.050740E-01
4.738170E 00	4.759609E 00	6.861050E 00	9.151500E-03	6.035730E-01
4.872649E 00	4.852030E 00	7.024240E 00	8.769218E-03	6.020970E-01
5.010619E 00	4.946549E 00	7.191480E 00	8.402657E-03	6.006490E-01
5.153000E 00	5.041770E 00	7.362760E 00	7.638928E-03	5.894300E-01
5.298670E 00	5.139819E 00	7.538360E 00	7.315997E-03	5.924670E-01
5.448739E 00	5.239030E 00	7.718260E 00	6.608158E-03	5.841110E-01
5.602759E 00	5.340369E 00	7.902630E 00	5.886339E-03	5.819899E-01
5.761080E 00	5.443469E 00	8.091559E 00	5.379148E-03	5.772009E-01
5.923739E 00	5.548479E 00	8.285170E 00	4.988506E-03	5.732610E-01
6.090810E 00	5.655530E 00	8.483589E 00	4.578840E-03	5.698510E-01
6.262309E 00	5.764799E 00	8.686939E 00	4.239608E-03	5.672830E-01
6.438490E 00	5.876120E 00	8.895350E 00	3.833990E-03	5.635310E-01
6.619380E 00	5.989710E 00	9.108939E 00	3.481260E-03	5.607100E-01
6.805059E 00	6.105659E 00	9.327860E 00	3.171240E-03	5.582120E-01
6.995780E 00	6.223829E 00	9.552219E 00	2.796320E-03	5.547100E-01
7.191600E 00	6.344390E 00	9.782169E 00	2.491480E-03	5.518349E-01
7.392449E 00	6.467719E 00	1.001790E 01	2.209980E-03	5.507140E-01
7.598740E 00	6.593410E 00	1.025940E 01	2.109600E-03	5.472220E-01
7.810149E 00	6.722300E 00	1.050700E 01	2.014450E-03	5.474910E-01
8.026890E 00	6.854340E 00	1.076080E 01	1.988210E-03	5.471660E-01
8.249129E 00	6.989550E 00	1.102100E 01	1.898000E-03	5.465630E-01
8.477039E 00	7.127930E 00	1.128760E 01	1.860710E-03	5.456730E-01
8.710569E 00	7.269899E 00	1.156090E 01	1.776380E-03	5.462450E-01
8.950000E 00	7.415310E 00	1.184100E 01	1.695850E-03	5.457529E-01
9.195499E 00	7.564230E 00	1.212820E 01	1.618950E-03	5.452720E-01
9.446870E 00	7.717310E 00	1.242250E 01	1.635870E-03	5.470020E-01
9.704720E 00	7.873890E 00	1.272410E 01	1.561920E-03	5.457259E-01
9.969100E 00	8.034260E 00	1.303330E 01	1.491310E-03	5.452490E-01
1.024020E 01	8.198500E 00	1.335030E 01	1.423860E-03	5.447820E-01
1.051750E 01	8.367680E 00	1.367520E 01	1.452850E-03	5.477050E-01
1.080220E 01	8.540440E 00	1.400810E 01	1.387420E-03	5.454880E-01
1.139310E 01	8.898820E 00	1.469930E 01	1.364680E-03	5.464930E-01
1.169960E 01	9.085030E 00	1.505790E 01	1.303540E-03	5.460100E-01
1.201380E 01	9.275749E 00	1.542540E 01	1.245120E-03	5.455360E-01
1.233590E 01	9.471080E 00	1.580220E 01	1.189320E-03	5.450730E-01
1.266610E 01	9.671340E 00	1.618829E 01	1.211860E-03	5.452130E-01
1.300440E 01	9.876820E 00	1.658420E 01	1.157820E-03	5.458170E-01
1.335130E 01	1.008730E 01	1.698990E 01	1.106190E-03	5.453530E-01
1.370690E 01	1.030280E 01	1.740569E 01	1.056840E-03	5.448980E-01
1.407150E 01	1.052360E 01	1.783199E 01	1.009700E-03	5.444530E-01
1.444470E 01	1.075080E 01	1.826889E 01	1.015710E-03	5.469060E-01
1.482770E 01	1.098290E 01	1.871669E 01	9.705969E-04	5.448720E-01
1.522030E 01	1.122060E 01	1.917569E 01	9.274799E-04	5.444320E-01
1.562290E 01	1.146420E 01	1.964619E 01	8.862719E-04	5.440010E-01
1.603519E 01	1.171430E 01	2.012839E 01	9.086698E-04	5.453990E-01
1.645789E 01	1.197060E 01	2.062279E 01	8.685738E-04	5.449330E-01
1.689130E 01	1.223300E 01	2.112939E 01	8.302419E-04	5.444980E-01
1.733559E 01	1.250180E 01	2.164879E 01	7.935958E-04	5.440720E-01
1.779070E 01	1.277810E 01	2.218109E 01	8.065440E-04	5.455640E-01
1.825729E 01	1.306080E 01	2.272670E 01	7.711819E-04	5.448200E-01
1.873569E 01	1.335050E 01	2.328600E 01	7.373649E-04	5.443940E-01
1.922589E 01	1.364770E 01	2.385919E 01	7.439549E-04	5.450079E-01
1.972839E 01	1.395230E 01	2.444679E 01	7.115440E-04	5.449980E-01
2.024350E 01	1.426430E 01	2.504909E 01	6.805419E-04	5.445750E-01
2.077150E 01	1.458420E 01	2.566640E 01	6.825628E-04	5.448260E-01
2.131259E 01	1.491230E 01	2.629919E 01	6.530120E-04	5.450570E-01
2.186729E 01	1.524830E 01	2.694769E 01	6.247358E-04	5.446380E-01
2.243579E 01	1.559290E 01	2.761249E 01	6.235340E-04	5.448750E-01
2.301849E 01	1.594620E 01	2.829390E 01	5.967019E-04	5.450180E-01
2.361589E 01	1.630800E 01	2.899239E 01	5.710218E-04	5.446060E-01
2.422809E 01	1.667920E 01	2.970830E 01	5.681140E-04	5.451300E-01
2.485559E 01	1.705959E 01	3.044209E 01	5.438149E-04	5.449250E-01
2.549889E 01	1.744930E 01	3.119429E 01	5.388530E-04	5.447090E-01
2.615810E 01	1.784909E 01	3.196519E 01	5.159448E-04	5.451609E-01
2.683400E 01	1.825859E 01	3.275549E 01	4.940080E-04	5.447590E-01
2.752669E 01	1.867839E 01	3.356540E 01	4.858158E-04	5.447740E-01
2.823669E 01	1.910869E 01	3.439569E 01	4.652629E-04	5.447870E-01
2.896469E 01	1.954939E 01	3.524669E 01	4.540388E-04	5.444230E-01
2.971078E 01	2.000130E 01	3.611890E 01	4.349009E-04	5.445930E-01
3.047549E 01	2.046449E 01	3.701299E 01	4.236810E-04	5.445810E-01
3.125949E 01	2.093909E 01	3.792940E 01	4.058848E-04	5.443590E-01
3.206339E 01	2.142490E 01	3.886870E 01	3.781149E-04	5.435579E-01
3.288820E 01	2.192139E 01	3.983150E 01	3.187228E-04	5.418670E-01\$

Shock Shape Input Data for the 140B

Orbiter Sample Cases

0.0	0.0	1.166000E-01
2.418570E-03	0.0	1.166000E-01
3.669430E-03	0.0	1.166000E-01
4.948799E-03	0.0	1.166000E-01
6.257258E-03	0.0	1.166000E-01
7.595427E-03	0.0	1.166000E-01
8.963928E-03	0.0	1.166000E-01
1.036340E-02	0.0	1.166000E-01
1.179440E-02	0.0	1.166000E-01
1.325770E-02	0.0	1.166000E-01
1.473920E-02	0.0	1.166000E-01
1.625160E-02	0.0	1.166000E-01
1.779790E-02	0.0	1.166000E-01
1.937870E-02	0.0	1.166000E-01
2.099480E-02	0.0	1.166000E-01
2.264690E-02	0.0	1.166000E-01
2.433570E-02	0.0	1.166000E-01
2.606200E-02	0.0	1.166000E-01
2.782640E-02	0.0	1.166000E-01
2.962990E-02	0.0	1.166000E-01
3.147300E-02	0.0	1.166000E-01
3.335670E-02	0.0	1.166000E-01
3.528170E-02	0.0	1.166000E-01
3.723310E-02	0.0	1.166000E-01
3.922130E-02	0.0	1.166000E-01
4.125280E-02	0.0	1.166000E-01
4.332860E-02	0.0	1.166000E-01
4.544930E-02	0.0	1.166000E-01
4.761610E-02	0.0	1.166000E-01
4.982960E-02	0.0	1.166000E-01
5.209090E-02	0.0	1.166000E-01
5.440090E-02	0.0	1.166000E-01
5.676050E-02	0.0	1.166000E-01
5.916430E-02	0.0	1.166000E-01
6.160030E-02	0.0	1.166000E-01
6.408817E-02	0.0	1.166000E-01
6.662905E-02	0.0	1.166000E-01
6.922400E-02	0.0	1.166000E-01
7.187378E-02	0.0	1.166000E-01
7.457978E-02	0.0	1.166000E-01
7.734287E-02	0.0	1.166000E-01
8.016419E-02	0.0	1.166000E-01
8.303237E-02	0.0	1.166000E-01
8.594429E-02	0.0	1.166000E-01
8.891720E-02	0.0	1.166000E-01
9.195215E-02	0.0	1.166000E-01
9.505045E-02	0.0	1.166000E-01
9.821337E-02	0.0	1.166000E-01
1.014420E-01	0.0	1.166000E-01
1.047380E-01	0.0	1.166000E-01
1.080779E-01	0.0	1.166000E-01
1.114790E-01	0.0	1.166000E-01
1.149499E-01	0.0	1.166000E-01
1.184930E-01	0.0	1.166000E-01
1.221090E-01	0.0	1.166000E-01
1.257989E-01	0.0	1.166000E-01
1.295649E-01	0.0	1.166000E-01
1.333770E-01	0.0	1.166000E-01
1.372640E-01	0.0	1.166000E-01
1.412309E-01	0.0	1.166000E-01
1.452790E-01	0.0	1.166000E-01
1.494090E-01	0.0	1.166000E-01
1.536230E-01	0.0	1.166000E-01
1.578979E-01	0.0	1.166000E-01
1.622500E-01	0.0	1.166000E-01
1.666890E-01	0.0	1.166000E-01
1.712199E-01	0.0	1.166000E-01
1.758420E-01	0.0	1.166000E-01
1.805570E-01	0.0	1.166000E-01
1.853319E-01	0.0	1.166000E-01
1.902030E-01	0.0	1.166000E-01
1.951730E-01	0.0	1.166000E-01
2.002439E-01	0.0	1.166000E-01
2.054180E-01	0.0	1.166000E-01
2.106690E-01	0.0	1.166000E-01

2.160169E-01	0.0	1.166000E-01
2.214730E-01	0.0	1.166000E-01
2.270390E-01	0.0	1.166000E-01
2.327180E-01	0.0	1.166000E-01
2.384850E-01	0.0	1.166000E-01
2.443590E-01	0.0	1.166000E-01
2.503520E-01	0.0	1.166000E-01
2.564670E-01	0.0	1.166000E-01
2.627040E-01	0.0	1.166000E-01
2.690340E-01	0.0	1.166000E-01
2.754920E-01	0.0	1.166000E-01
2.820820E-01	0.0	1.166000E-01
2.888070E-01	0.0	1.166000E-01
2.980940E-01	0.0	1.166000E-01
3.056250E-01	0.0	1.166000E-01
3.133079E-01	0.0	1.166000E-01
3.211460E-01	0.0	1.166000E-01
3.288360E-01	0.0	1.166000E-01
3.372729E-01	0.0	1.166000E-01
3.458790E-01	0.0	1.166000E-01
3.546570E-01	0.0	1.166000E-01
3.626429E-01	0.0	1.166000E-01
3.717080E-01	0.0	1.166000E-01
3.809550E-01	0.0	1.166000E-01
3.904510E-01	0.0	1.166000E-01
3.999910E-01	0.0	1.166000E-01
4.097250E-01	0.0	1.166000E-01
4.196570E-01	0.0	1.166000E-01
4.297900E-01	0.0	1.166000E-01
4.401290E-01	0.0	1.166000E-01
4.506789E-01	0.0	1.166000E-01
4.614429E-01	0.0	1.166000E-01
4.724280E-01	0.0	1.166000E-01
4.836370E-01	0.0	1.166000E-01
4.950750E-01	0.0	1.166000E-01
5.067490E-01	0.0	1.166000E-01
5.186620E-01	0.0	1.166000E-01
5.308200E-01	0.0	1.166000E-01
5.432290E-01	0.0	1.166000E-01
5.558950E-01	0.0	1.166000E-01
5.688230E-01	0.0	1.166000E-01
5.820180E-01	0.0	1.166000E-01
5.954880E-01	0.0	1.166000E-01
6.092390E-01	0.0	1.166000E-01
6.232760E-01	0.0	1.166000E-01
6.373560E-01	0.0	1.166000E-01
6.518260E-01	0.0	1.166000E-01
6.666009E-01	0.0	1.166000E-01
6.816880E-01	0.0	1.166000E-01
6.970950E-01	0.0	1.166000E-01
7.128280E-01	0.0	1.166000E-01
7.288949E-01	0.0	1.166000E-01
7.453049E-01	0.0	1.166000E-01
7.620650E-01	0.0	1.166000E-01
7.791840E-01	0.0	1.166000E-01
7.966710E-01	0.0	1.166000E-01
8.145330E-01	0.0	1.166000E-01
8.327810E-01	0.0	1.166000E-01
8.514220E-01	0.0	1.166000E-01
8.715740E-01	0.0	1.166000E-01
8.908250E-01	0.0	1.166000E-01
9.104960E-01	0.0	1.166000E-01
9.305980E-01	0.0	1.166000E-01
9.511420E-01	0.0	1.166000E-01
9.721380E-01	0.0	1.166000E-01
9.935970E-01	0.0	1.166000E-01
1.015530E 00	0.0	1.166000E-01
1.037950E 00	0.0	1.166000E-01
1.060869E 00	0.0	1.166000E-01
1.084169E 00	0.0	1.166000E-01
1.107969E 00	0.0	1.166000E-01
1.132319E 00	0.0	1.166000E-01
1.157200E 00	0.0	1.166000E-01
1.182659E 00	0.0	1.166000E-01
1.208679E 00	0.0	1.166000E-01

1.235299E 00	0.0	1.166000E-01
1.262509E 00	0.0	1.166000E-01
1.290350E 00	0.0	1.166000E-01
1.318820E 00	0.0	1.166000E-01
1.347950E 00	0.0	1.166000E-01
1.377729E 00	0.0	1.166000E-01
1.408210E 00	0.0	1.166000E-01
1.439380E 00	0.0	1.166000E-01
1.471270E 00	0.0	1.166000E-01
1.503519E 00	0.0	1.166000E-01
1.536750E 00	0.0	1.166000E-01
1.570740E 00	0.0	1.166000E-01
1.605530E 00	0.0	1.166000E-01
1.641129E 00	0.0	1.166000E-01
1.677569E 00	0.0	1.166000E-01
1.714849E 00	0.0	1.166000E-01
1.752999E 00	0.0	1.166000E-01
1.792049E 00	0.0	1.166000E-01
1.832020E 00	0.0	1.166000E-01
1.872930E 00	0.0	1.166000E-01
1.914650E 00	0.0	1.166000E-01
1.957359E 00	0.0	1.166000E-01
2.001080E 00	0.0	1.166000E-01
2.045850E 00	0.0	1.166000E-01
2.091669E 00	0.0	1.166000E-01
2.138590E 00	0.0	1.166000E-01
2.186629E 00	0.0	1.166000E-01
2.235809E 00	0.0	1.166000E-01
2.286160E 00	0.0	1.166000E-01
2.337720E 00	0.0	1.166000E-01
2.390510E 00	0.0	1.166000E-01
2.444570E 00	0.0	1.166000E-01
2.499929E 00	0.0	1.166000E-01
2.556620E 00	0.0	1.166000E-01
2.614659E 00	0.0	1.166000E-01
2.673699E 00	0.0	1.166000E-01
2.734409E 00	0.0	1.166000E-01
2.796590E 00	0.0	1.166000E-01
2.860270E 00	0.0	1.166000E-01
2.925489E 00	0.0	1.166000E-01
2.992299E 00	0.0	1.166000E-01
3.060730E 00	0.0	1.166000E-01
3.130819E 00	0.0	1.166000E-01
3.202609E 00	0.0	1.166000E-01
3.276159E 00	0.0	1.166000E-01
3.351489E 00	0.0	1.166000E-01
3.428659E 00	0.0	1.166000E-01
3.507090E 00	0.0	1.166000E-01
3.587910E 00	0.0	1.166000E-01
3.670699E 00	0.0	1.166000E-01
3.755529E 00	0.0	1.166000E-01
3.842429E 00	0.0	1.166000E-01
3.931459E 00	0.0	1.166000E-01
4.022679E 00	0.0	1.166000E-01
4.116130E 00	0.0	1.166000E-01
4.211619E 00	0.0	1.166000E-01
4.309520E 00	0.0	1.166000E-01
4.409840E 00	0.0	1.166000E-01
4.512620E 00	0.0	1.166000E-01
4.617940E 00	0.0	1.166000E-01
4.725860E 00	0.0	1.166000E-01
4.836450E 00	0.0	1.166000E-01
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5.065599E 00	0.0	1.166000E-01
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5.306170E 00	0.0	1.166000E-01
5.430949E 00	0.0	1.166000E-01
5.558809E 00	0.0	1.166000E-01
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5.824039E 00	0.0	1.166000E-01
5.961539E 00	0.0	1.166000E-01
6.102440E 00	0.0	1.166000E-01
6.246849E 00	0.0	1.166000E-01
6.394839E 00	0.0	1.166000E-01
6.546479E 00	0.0	1.166000E-01

6.701839E	00	0.0	1.166000E-01
6.861050E	00	0.0	1.166000E-01
7.024240E	00	0.0	1.166000E-01
7.191480E	00	0.0	1.166000E-01
7.362760E	00	0.0	1.166000E-01
7.538360E	00	0.0	1.166000E-01
7.718260E	00	0.0	1.166000E-01
7.902630E	00	0.0	1.166000E-01
8.091559E	00	0.0	1.166000E-01
8.285170E	00	0.0	1.166000E-01
8.483589E	00	0.0	1.166000E-01
8.686939E	00	0.0	1.166000E-01
8.895350E	00	0.0	1.166000E-01
9.108939E	00	0.0	1.166000E-01
9.327860E	00	0.0	1.166000E-01
9.552219E	00	0.0	1.166000E-01
9.782169E	00	0.0	1.166000E-01
1.001790E	01	0.0	1.166000E-01
1.025940E	01	0.0	1.166000E-01
1.050700E	01	0.0	1.166000E-01
1.076080E	01	0.0	1.166000E-01
1.102100E	01	0.0	1.166000E-01
1.128760E	01	0.0	1.166000E-01
1.156090E	01	0.0	1.166000E-01
1.184100E	01	0.0	1.166000E-01
1.212820E	01	0.0	1.166000E-01
1.242250E	01	0.0	1.166000E-01
1.272410E	01	0.0	1.166000E-01
1.303330E	01	0.0	1.166000E-01
1.335030E	01	0.0	1.166000E-01
1.367520E	01	0.0	1.166000E-01
1.400810E	01	0.0	1.166000E-01
1.434940E	01	0.0	1.166000E-01
1.469930E	01	0.0	1.166000E-01
1.505790E	01	0.0	1.166000E-01
1.542540E	01	0.0	1.166000E-01
1.580220E	01	0.0	1.166000E-01
1.618829E	01	0.0	1.166000E-01
1.658420E	01	0.0	1.166000E-01
1.698990E	01	0.0	1.166000E-01
1.740569E	01	0.0	1.166000E-01
1.783199E	01	0.0	1.166000E-01
1.826889E	01	0.0	1.166000E-01
1.871669E	01	0.0	1.166000E-01
1.917569E	01	0.0	1.166000E-01
1.964619E	01	0.0	1.166000E-01
2.012839E	01	0.0	1.166000E-01
2.062279E	01	0.0	1.166000E-01
2.112939E	01	0.0	1.166000E-01
2.164879E	01	0.0	1.166000E-01
2.218109E	01	0.0	1.166000E-01
2.272670E	01	0.0	1.166000E-01
2.328600E	01	0.0	1.166000E-01
2.385919E	01	0.0	1.166000E-01
2.444679E	01	0.0	1.166000E-01
2.504909E	01	0.0	1.166000E-01
2.566640E	01	0.0	1.166000E-01
2.629919E	01	0.0	1.166000E-01
2.694769E	01	0.0	1.166000E-01
2.761249E	01	0.0	1.166000E-01
2.829390E	01	0.0	1.166000E-01
2.899239E	01	0.0	1.166000E-01
2.970830E	01	0.0	1.166000E-01
3.044209E	01	0.0	1.166000E-01
3.119429E	01	0.0	1.166000E-01
3.196519E	01	0.0	1.166000E-01
3.275549E	01	0.0	1.166000E-01
3.356540E	01	0.0	1.166000E-01
3.439569E	01	0.0	1.166000E-01
3.524669E	01	0.0	1.166000E-01
3.611890E	01	0.0	1.166000E-01
3.701299E	01	0.0	1.166000E-01
3.792940E	01	0.0	1.166000E-01
3.886870E	01	0.0	1.166000E-01
3.983150E	01	0.0	1.166000E-01*

Unit 5 Input Data for the 140B Orbiter

Binary-Gas Sample Case

FREE FLIGHT 140B ORBITER ALT=245K FT. M=26.9 ALPHA=30, BINARY-GAS

&INPUT

ALT=245000.0,

BRAD=2.360833,

DS=0.2,

DSMAX=1.0,

RINF=.867251028D-07,

SEND=35.0,

TB=2460.0,

THINI=-1.,

TINF=361.48,

UINF=25100.0,

XKETA=1.05,

IEND=6,

IGECM=3,

KEND=1,

NAN=-2,

NDATA=1,

NS=2,

NSI=2,

NTSH=20,

&END

.23456

.23456

.76544

.76544

Unit 5 Input Data for the 140B Orbiter

7-Species Sample Case

FREE FLIGHT 140B ORBITER ALT=245K FT. M=26.9 ALPHA=30, 7-SPECIES

&INPUT

ALT=245000.0,

BRAD=2.360833,

DS=0.2,

DSMAX=1.0,

RINF=.867251028D-07,

SEND=35.0,

TB=2460.0,

THINI=-1.,

TINF=361.48,

UINF=25100.0,

XKETA=1.05,

IEND=6,

IGECM=3,

KEND=1,

NAN=-2,

NDATA=1,

NS=6,

NSI=6,

NTSH=20,

&END

.23456

.23456

.76544

.76544

Shock Shape Input Data for the
31° Hyperboloid Sample Cases

0.0	0.0	1.166000E-01
2.943361E-02	0.0	1.166000E-01
5.886861E-02	0.0	1.166000E-01
8.830637E-02	0.0	1.166000E-01
1.177483E-01	0.0	1.166000E-01
1.471957E-01	0.0	1.166000E-01
1.766500E-01	0.0	1.166000E-01
2.061127E-01	0.0	1.166000E-01
2.355852E-01	0.0	1.166000E-01
2.650688E-01	0.0	1.166000E-01
2.945648E-01	0.0	1.166000E-01
3.240746E-01	0.0	1.166000E-01
3.535998E-01	0.0	1.166000E-01
3.831417E-01	0.0	1.166000E-01
4.127015E-01	0.0	1.166000E-01
4.422811E-01	0.0	1.166000E-01
4.718814E-01	0.0	1.166000E-01
5.015042E-01	0.0	1.166000E-01
5.311506E-01	0.0	1.166000E-01
5.608222E-01	0.0	1.166000E-01
5.905204E-01	0.0	1.166000E-01
6.202466E-01	0.0	1.166000E-01
6.500025E-01	0.0	1.166000E-01
6.797891E-01	0.0	1.166000E-01
7.096082E-01	0.0	1.166000E-01
7.394611E-01	0.0	1.166000E-01
7.693492E-01	0.0	1.166000E-01
7.992741E-01	0.0	1.166000E-01
8.292373E-01	0.0	1.166000E-01
8.592403E-01	0.0	1.166000E-01
8.892844E-01	0.0	1.166000E-01
9.193712E-01	0.0	1.166000E-01
9.495023E-01	0.0	1.166000E-01
9.796793E-01	0.0	1.166000E-01
1.009903E 00	0.0	1.166000E-01
1.040175E 00	0.0	1.166000E-01
1.070499E 00	0.0	1.166000E-01
1.100875E 00	0.0	1.166000E-01
1.131304E 00	0.0	1.166000E-01
1.161786E 00	0.0	1.166000E-01
1.192327E 00	0.0	1.166000E-01
1.222926E 00	0.0	1.166000E-01
1.253585E 00	0.0	1.166000E-01
1.284305E 00	0.0	1.166000E-01
1.315087E 00	0.0	1.166000E-01
1.345936E 00	0.0	1.166000E-01
1.376850E 00	0.0	1.166000E-01
1.407832E 00	0.0	1.166000E-01
1.438885E 00	0.0	1.166000E-01
1.470009E 00	0.0	1.166000E-01
1.501205E 00	0.0	1.166000E-01
1.532476E 00	0.0	1.166000E-01
1.563826E 00	0.0	1.166000E-01
1.595253E 00	0.0	1.166000E-01
1.626760E 00	0.0	1.166000E-01
1.658348E 00	0.0	1.166000E-01
1.690022E 00	0.0	1.166000E-01
1.721781E 00	0.0	1.166000E-01
1.753627E 00	0.0	1.166000E-01
1.785562E 00	0.0	1.166000E-01
1.817589E 00	0.0	1.166000E-01
1.849709E 00	0.0	1.166000E-01
1.881924E 00	0.0	1.166000E-01
1.914235E 00	0.0	1.166000E-01
1.946647E 00	0.0	1.166000E-01
1.979158E 00	0.0	1.166000E-01
2.011773E 00	0.0	1.166000E-01
2.044494E 00	0.0	1.166000E-01
2.077320E 00	0.0	1.166000E-01
2.110257E 00	0.0	1.166000E-01
2.143305E 00	0.0	1.166000E-01
2.176466E 00	0.0	1.166000E-01
2.209742E 00	0.0	1.166000E-01
2.243136E 00	0.0	1.166000E-01
2.276650E 00	0.0	1.166000E-01

2.310287E	00	0.0	1.166000E-01
2.344047E	00	0.0	1.166000E-01
2.377934E	00	0.0	1.166000E-01
2.411950E	00	0.0	1.166000E-01
2.446098E	00	0.0	1.166000E-01
2.480379E	00	0.0	1.166000E-01
2.514797E	00	0.0	1.166000E-01
2.549354E	00	0.0	1.166000E-01
2.584050E	00	0.0	1.166000E-01
2.618892E	00	0.0	1.166000E-01
2.653878E	00	0.0	1.166000E-01
2.689014E	00	0.0	1.166000E-01
2.724301E	00	0.0	1.166000E-01
2.759743E	00	0.0	1.166000E-01
2.795340E	00	0.0	1.166000E-01
2.831097E	00	0.0	1.166000E-01
2.867016E	00	0.0	1.166000E-01
2.903099E	00	0.0	1.166000E-01
2.939351E	00	0.0	1.166000E-01
2.975775E	00	0.0	1.166000E-01
3.012370E	00	0.0	1.166000E-01
3.049144E	00	0.0	1.166000E-01
3.086096E	00	0.0	1.166000E-01
3.123231E	00	0.0	1.166000E-01
3.160551E	00	0.0	1.166000E-01
3.198062E	00	0.0	1.166000E-01
3.235764E	00	0.0	1.166000E-01
3.273661E	00	0.0	1.166000E-01
3.311756E	00	0.0	1.166000E-01
3.350056E	00	0.0	1.166000E-01
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3.951264E	00	0.0	1.166000E-01
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4.121061E	00	0.0	1.166000E-01
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4.384356E	00	0.0	1.166000E-01
4.429307E	00	0.0	1.166000E-01
4.474577E	00	0.0	1.166000E-01
4.520170E	00	0.0	1.166000E-01
4.566095E	00	0.0	1.166000E-01
4.612356E	00	0.0	1.166000E-01
4.658960E	00	0.0	1.166000E-01
4.705913E	00	0.0	1.166000E-01
4.753219E	00	0.0	1.166000E-01
4.800885E	00	0.0	1.166000E-01
4.848920E	00	0.0	1.166000E-01
4.897327E	00	0.0	1.166000E-01
4.946115E	00	0.0	1.166000E-01
4.995291E	00	0.0	1.166000E-01
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5.145209E	00	0.0	1.166000E-01
5.196005E	00	0.0	1.166000E-01
5.247223E	00	0.0	1.166000E-01
5.298873E	00	0.0	1.166000E-01
5.350962E	00	0.0	1.166000E-01

5.403499E	00	0.0	1.166000E-01
5.456491E	00	0.0	1.166000E-01
5.509947E	00	0.0	1.166000E-01
5.563875E	00	0.0	1.166000E-01
5.618285E	00	0.0	1.166000E-01
5.673186E	00	0.0	1.166000E-01
5.728588E	00	0.0	1.166000E-01
5.784498E	00	0.0	1.166000E-01
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6.562467E	00	0.0	1.166000E-01
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6.757072E	00	0.0	1.166000E-01
6.823245E	00	0.0	1.166000E-01
6.890345E	00	0.0	1.166000E-01
6.958087E	00	0.0	1.166000E-01
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7.236790E	00	0.0	1.166000E-01
7.308482E	00	0.0	1.166000E-01
7.381019E	00	0.0	1.166000E-01
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7.756994E	00	0.0	1.166000E-01
7.834990E	00	0.0	1.166000E-01
7.913967E	00	0.0	1.166000E-01
7.993950E	00	0.0	1.166000E-01
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8.157023E	00	0.0	1.166000E-01
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8.496301E	00	0.0	1.166000E-01
8.584008E	00	0.0	1.166000E-01
8.672928E	00	0.0	1.166000E-01
8.763088E	00	0.0	1.166000E-01
8.854520E	00	0.0	1.166000E-01
8.947254E	00	0.0	1.166000E-01
9.041325E	00	0.0	1.166000E-01
9.136765E	00	0.0	1.166000E-01
9.233607E	00	0.0	1.166000E-01
9.331889E	00	0.0	1.166000E-01
9.431649E	00	0.0	1.166000E-01
9.532924E	00	0.0	1.166000E-01
9.635753E	00	0.0	1.166000E-01
9.740177E	00	0.0	1.166000E-01
9.846241E	00	0.0	1.166000E-01
9.953984E	00	0.0	1.166000E-01
1.006346E	01	0.0	1.166000E-01
1.017471E	01	0.0	1.166000E-01
1.028778E	01	0.0	1.166000E-01
1.040272E	01	0.0	1.166000E-01
1.051959E	01	0.0	1.166000E-01
1.063845E	01	0.0	1.166000E-01
1.075934E	01	0.0	1.166000E-01
1.088233E	01	0.0	1.166000E-01
1.100747E	01	0.0	1.166000E-01
1.113484E	01	0.0	1.166000E-01
1.126449E	01	0.0	1.166000E-01
1.139650E	01	0.0	1.166000E-01
1.153093E	01	0.0	1.166000E-01

1.166787E	01	0.0	1.166000E-01
1.180738E	01	0.0	1.166000E-01
1.194955E	01	0.0	1.166000E-01
1.209446E	01	0.0	1.166000E-01
1.224220E	01	0.0	1.166000E-01
1.239286E	01	0.0	1.166000E-01
1.254653E	01	0.0	1.166000E-01
1.270331E	01	0.0	1.166000E-01
1.286331E	01	0.0	1.166000E-01
1.302663E	01	0.0	1.166000E-01
1.319339E	01	0.0	1.166000E-01
1.336370E	01	0.0	1.166000E-01
1.353769E	01	0.0	1.166000E-01
1.371548E	01	0.0	1.166000E-01
1.389721E	01	0.0	1.166000E-01
1.408302E	01	0.0	1.166000E-01
1.427307E	01	0.0	1.166000E-01
1.446749E	01	0.0	1.166000E-01
1.466647E	01	0.0	1.166000E-01
1.487016E	01	0.0	1.166000E-01
1.507875E	01	0.0	1.166000E-01
1.529243E	01	0.0	1.166000E-01
1.551140E	01	0.0	1.166000E-01
1.573586E	01	0.0	1.166000E-01
1.596604E	01	0.0	1.166000E-01
1.620216E	01	0.0	1.166000E-01
1.644449E	01	0.0	1.166000E-01
1.669325E	01	0.0	1.166000E-01
1.694875E	01	0.0	1.166000E-01
1.721127E	01	0.0	1.166000E-01
1.748111E	01	0.0	1.166000E-01
1.775859E	01	0.0	1.166000E-01
1.804407E	01	0.0	1.166000E-01
1.833788E	01	0.0	1.166000E-01
1.864044E	01	0.0	1.166000E-01
1.895215E	01	0.0	1.166000E-01
1.927344E	01	0.0	1.166000E-01
1.960478E	01	0.0	1.166000E-01
1.994667E	01	0.0	1.166000E-01
2.029964E	01	0.0	1.166000E-01
2.066425E	01	0.0	1.166000E-01
2.104109E	01	0.0	1.166000E-01
2.143082E	01	0.0	1.166000E-01
2.183414E	01	0.0	1.166000E-01
2.225177E	01	0.0	1.166000E-01
2.268454E	01	0.0	1.166000E-01
2.313326E	01	0.0	1.166000E-01
2.359889E	01	0.0	1.166000E-01
2.408243E	01	0.0	1.166000E-01
2.458493E	01	0.0	1.166000E-01
2.510757E	01	0.0	1.166000E-01
2.565161E	01	0.0	1.166000E-01
2.621843E	01	0.0	1.166000E-01
2.680949E	01	0.0	1.166000E-01
2.742644E	01	0.0	1.166000E-01
2.807103E	01	0.0	1.166000E-01
2.874519E	01	0.0	1.166000E-01
2.945105E	01	0.0	1.166000E-01
3.019095E	01	0.0	1.166000E-01
3.096741E	01	0.0	1.166000E-01
3.178326E	01	0.0	1.166000E-01
3.264165E	01	0.0	1.166000E-01
3.354601E	01	0.0	1.166000E-01
3.450018E	01	0.0	1.166000E-01
3.550845E	01	0.0	1.166000E-01
3.657561E	01	0.0	1.166000E-01
3.770702E	01	0.0	1.166000E-01
3.890871E	01	0.0	1.166000E-01
4.018752E	01	0.0	1.166000E-01
4.155119E	01	0.0	1.166000E-01
4.300851E	01	0.0	1.166000E-01
4.456956E	01	0.0	1.166000E-01
4.624590E	01	0.0	1.166000E-01
4.805089E	01	0.0	1.166000E-01
5.000000E	01	0.0	1.166000E-01

Unit 5 Input Data for the 31° Hyperboloid
Binary-Gas Sample Case

FREE FLIGHT 31DEG HYPER ALT=245K FT. M=26.9 ALPHA=30, BINARY-GAS
&INPUT
ALT=245000.0,
BRAD=2.360833,
DS=0.2,
DSMAX=3.0,
HANGLE=31.0,
RINF=.867251028D-07,
SEND=43.0,
TB=2460.0,
THINI=-1.,
TINF=361.48,
UINF=25100.0,
XKETA=1.05,
IEND=6,
IGECM=1,
KEND=1,
NAN=1,
NDATA=1,
NS=2,
NSI=2,
NTSH=20,
&END

.23456
.23456

.76544
.76544

Unit 5 Input Data for the 31° Hyperboloid

7-Species Sample Case

FREE FLIGHT 31DEG HYPER ALT=245K FT. M=26.9 ALPHA=30, 7-SPECIES

&INPUT

ALT=245000.0,

BRAD=2.360833,

DS=0.2,

DSMAX=3.0,

HANGLE=31.0,

RINF=.867251028D-07,

SEND=43.0,

TB=2460.0,

THINI=-1.,

TINF=361.48,

UINF=25100.0,

XKETA=1.05,

IEND=6,

IGECM=1,

KEND=1,

NAN=1,

NDATA=1,

NS=6,

NSI=6,

NTSH=20,

&END

.23456

.23456

.76544

.76544

Listing of the Unit 6 Output Data for the 140B Orbiter Binary-Gas Sample Case

FREE FLIGHT 140B ORBITER ALT=245K FT. M=26.9 ALPHA=30, BINARY-GAS

```

&INPUT
ALT= 245000.0000000000 ,BRAD= 2.36083300000000 ,CAINF= 0.0 ,CAT= 1.00000000000000 ,CAW=
0.0 ,CCFAC= 0.0 ,CONVRG= 0.9999997913837432D-02,DS= 0.200000000000000 ,DSMAX=
1.00000000000000 ,HANGLE= 10.00000000000000 ,PRNTCI= 0.0 ,RINF= 0.867251027999999D-07,SEND=
35.0000000000000 ,SIGM= 0.6999999880790710 ,SITEST= 0.9999999019782990D-04,SMALLT= 0.9999994290410541D-06,SSFAC=
-1.00000000000000 ,SHFAC= -1.00000000000000 ,TB= 2460.000000000000 ,THINI= -1.00000000000000 ,TINF=
361.480000000000 ,UFAC= 0.500000000000000 ,UINF= 25100.000000000000 ,WVFAC= 0.250000000000000 ,XKETA=
1.05000000000000 ,XLE= 1.399999618530273 ,XNSO= 0.1165995770164490 ,IE= 51,IEND= 6,IGEOM= 3,
IUN= 19,JFAC= 1,KEND= 1,KPLTTP= 0,KTWAL= 0,NAN= -2,NDATA= 1,NITMAX= 3,
9999,NITMIN= 3,NITMNI= 3,NS= 2,NSI= 2,NSPRF= 0,NTSH= 20,NTTWA=
5
&END

```

LOG RATES MATCH & SPECIE BLOTTNER-SANDIA

NR	REACTION	CRG	EXP(CRG)	CR1	CR2	DRO	EXP(DRO)	DR1	DR2
1	O2 O2 =O O C2	44.9274640	0.3249D 20	59400.0	-1.0	37.8379411	0.2709D 17	0.0	-0.5
2	O2 O =O C C	45.9491153	0.9025D 20	59400.0	-1.0	38.8595923	0.7525D 17	0.0	-0.5

ALPHSB(2, 2)

NR	ALSUB	NR	O	O2
1	1.0	1	0.	2.
2	1.0	2	1.	1.

BETASB(2, 2)

NR	BETSUB	NR	O	O2
1	2.0	1	2.	1.
2	2.0	2	3.	0.

GAMMPL(2, 2)

1	2.	0.
2	2.	0.

GAMMMI(2, 2)

1	0.	1.
2	0.	1.

VSREF = 0.19332065D-04

VSINF = 0.46451309D-06

97

K =1, I = 1, S = 0.0	, NITER = 1, DIFI = 3.900D-01	2.544D-00	0.0	1.000D-00
K =1, I = 1, S = 0.0	, NITER = 2, DIFI = 4.802D-01	1.944D-00	4.395D-01	1.073D-04
K =1, I = 1, S = 0.0	, NITER = 3, DIFI = 3.722D-01	2.615D-01	2.169D-01	3.553D-01
K =1, I = 1, S = 0.0	, NITER = 4, DIFI = 9.725D-02	3.613D-01	7.576D-02	1.696D-01
K =1, I = 1, S = 0.0	, NITER = 5, DIFI = 1.280D-01	3.756D-01	3.625D-01	4.820D-01
K =1, I = 1, S = 0.0	, NITER = 6, DIFI = 8.850D-02	2.793D-01	3.368D-01	5.120D-00
K =1, I = 1, S = 0.0	, NITER = 7, DIFI = 5.875D-02	5.058D-02	1.091D-01	1.686D-00
K =1, I = 1, S = 0.0	, NITER = 8, DIFI = 5.028D-02	5.279D-02	4.782D-02	1.537D-00
K =1, I = 1, S = 0.0	, NITER = 9, DIFI = 6.379D-02	4.067D-02	8.176D-02	1.463D-00
K =1, I = 1, S = 0.0	, NITER = 10, DIFI = 5.112D-02	2.960D-02	6.005D-02	1.075D-00
K =1, I = 1, S = 0.0	, NITER = 11, DIFI = 4.192D-02	2.444D-02	4.478D-02	7.984D-01
K =1, I = 1, S = 0.0	, NITER = 12, DIFI = 3.646D-02	2.144D-02	3.907D-02	6.252D-01
K =1, I = 1, S = 0.0	, NITER = 13, DIFI = 3.159D-02	1.835D-02	3.485D-02	4.929D-01
K =1, I = 1, S = 0.0	, NITER = 14, DIFI = 2.693D-02	1.538D-02	3.009D-02	3.877D-01
K =1, I = 1, S = 0.0	, NITER = 15, DIFI = 2.280D-02	1.286D-02	2.554D-02	3.071D-01
K =1, I = 1, S = 0.0	, NITER = 16, DIFI = 1.928D-02	1.077D-02	2.165D-02	2.458D-01
K =1, I = 1, S = 0.0	, NITER = 17, DIFI = 1.627D-02	9.005D-03	1.835D-02	1.979D-01
K =1, I = 1, S = 0.0	, NITER = 18, DIFI = 1.370D-02	7.512D-03	1.551D-02	1.600D-01
K =1, I = 1, S = 0.0	, NITER = 19, DIFI = 1.150D-02	6.252D-03	1.305D-02	1.297D-01
K =1, I = 1, S = 0.0	, NITER = 20, DIFI = 9.628D-03	5.197D-03	1.096D-02	1.057D-01
K =1, I = 1, S = 0.0	, NITER = 21, DIFI = 8.052D-03	4.316D-03	9.180D-03	8.646D-02
K =1, I = 1, S = 0.0	, NITER = 22, DIFI = 6.665D-03	3.580D-03	7.678D-03	7.086D-02
K =1, I = 1, S = 0.0	, NITER = 23, DIFI = 5.142D-03	2.716D-03	5.377D-03	5.106D-02
K =1, I = 1, S = 0.0	, NITER = 24, DIFI = 4.770D-03	2.645D-03	4.939D-03	4.738D-02
K =1, I = 1, S = 0.0	, NITER = 25, DIFI = 4.136D-03	2.311D-03	4.616D-03	4.233D-02
K =1, I = 1, S = 0.0	, NITER = 26, DIFI = 3.444D-03	1.902D-03	4.017D-03	3.590D-02
K =1, I = 1, S = 0.0	, NITER = 27, DIFI = 2.842D-03	1.548D-03	3.393D-03	2.982D-02
K =1, I = 1, S = 0.0	, NITER = 28, DIFI = 2.350D-03	1.259D-03	2.843D-03	2.458D-02
K =1, I = 1, S = 0.0	, NITER = 29, DIFI = 1.946D-03	1.019D-03	2.369D-03	2.013D-02
K =1, I = 1, S = 0.0	, NITER = 30, DIFI = 1.608D-03	8.193D-04	1.963D-03	1.636D-02
K =1, I = 1, S = 0.0	, NITER = 31, DIFI = 1.324D-03	6.552D-04	1.618D-03	1.323D-02
K =1, I = 1, S = 0.0	, NITER = 32, DIFI = 1.085D-03	5.221D-04	1.327D-03	1.067D-02
K =1, I = 1, S = 0.0	, NITER = 33, DIFI = 8.858D-04	4.152D-04	1.084D-03	8.580D-03

UINF	PINF	TINF	CAINF	TB	BRAD	PR	LE	YSH	ALT
C.251D 05	0.48676D-01	0.36148D 03	C.0	0.2460D 04	0.2361D 01	0.70D 00	0.14D 01	0.4354D-01	0.245D 06

THIN SHOCK LAYER NC WALL SLIP NC SHOCK SLIP CAT WALL NC STEPS IN Y= 51 NO STFPS IN S= 6 S STEP SIZE=0.200

TW/TS	EPS	REYINF	REYSH	TREF	UREF	RREF	PREF	ITER
0.0638	0.0613	0.1106D 05	0.6611D 03	0.1147D 06	0.2510D 05	0.8673D-07	0.5464D 02	1

**** FREE FLIGHT 14GB ORBITER ALT=245K FT. M=26.9 ALPHA=30, BINARY-GAS

S	X	R	YSH	YSHP	XSH	RSH	NO ITER	NITTOT	NTOT	I	K
0.0	0.0	0.0	0.043541	0.0	-0.043541	0.0	33	33	33	1	1
DS	CF	HEAT	STAN	CDF	CDP	CDTOT	PWALL	TWALL	PW/PO		
0.200000	0.0	0.043937	0.091651	0.0	1.751458	1.751458	0.875729	2460.000000	1.000000		
YSHP (S	YSHP (S+DS/2	NEW YSHP	ALPHA(S+DS/2	PHI(S+DS/2	KAPPA(S	KAPPA(S+DS/2					
0.0	0.000000	0.0	1.444297	1.444297	1.000000	0.977685					
USH	VSH	TSH	RSH	PSH	VPG						
0.0	-0.105425	0.331071	9.409600	0.880391	0.0						
0.0	-2646.17	37963.65									
		21090.92									

N	Y/YSH	U/USH	V/VSH	T/TSH	R/RSR	P/PSH(APPR)	P/PSH	CA	CAEQ	XM	T DEG R
1	0.0	0.0	0.0	0.064799	15.350654	0.994705	1.064659	0.0	0.000002	0.0	2460.00
2	0.004777	0.035621	0.000088	0.080200	11.723069	0.994705	1.064659	0.058053	0.000164	0.000102	3044.68
3	0.009792	0.068436	0.000398	0.093896	9.530513	0.994706	1.064660	0.111651	0.002262	0.000421	3564.62
4	0.015059	0.099311	0.000561	0.106465	8.039284	0.994708	1.064662	0.162270	0.013942	0.000938	4041.81
5	0.020588	0.128733	0.001804	0.118217	6.950163	0.994712	1.064665	0.210750	0.053291	0.001644	4487.97
6	0.026394	0.157008	0.002956	0.129342	6.115703	0.994718	1.064668	0.257606	0.146813	0.002531	4910.28
7	0.032491	0.184334	0.004443	0.139960	5.454101	0.994725	1.064672	0.303172	0.312377	0.003597	5313.38
8	0.038892	0.210848	0.006295	0.150153	4.915986	0.994734	1.064675	0.347667	0.529330	0.004840	5700.36
9	0.045614	0.236643	0.008540	0.159977	4.469627	0.994746	1.064677	0.391234	0.732473	0.006259	6073.30
10	0.052671	0.261784	0.011207	0.169468	4.093570	0.994759	1.064678	0.433968	0.867856	0.007856	6433.63
11	0.060081	0.286314	0.014326	0.178657	3.772693	0.994775	1.064675	0.475917	0.937851	0.009633	6782.46
12	0.067862	0.310261	0.017927	0.187567	3.495974	0.994793	1.064668	0.517092	0.970129	0.011593	7120.73
13	0.076032	0.333641	0.022040	0.196226	3.255124	0.994814	1.064656	0.557465	0.984880	0.013737	7449.46
14	0.084610	0.356459	0.026697	0.204665	3.043756	0.994837	1.064637	0.596971	0.991893	0.016070	7769.83
15	0.093617	0.378715	0.031931	0.212921	2.856861	0.994863	1.064609	0.635512	0.995415	0.018594	8083.25
16	0.103075	0.400401	0.037776	0.221037	2.690448	0.994892	1.064570	0.672282	0.997282	0.021318	8391.39
17	0.113006	0.421506	0.044269	0.229065	2.541303	0.994923	1.064519	0.709125	0.998324	0.024246	8696.14
18	0.123433	0.442017	0.051448	0.237060	2.406812	0.994958	1.064453	0.743841	0.998932	0.027384	8999.66
19	0.134381	0.461919	0.059352	0.245081	2.284858	0.994995	1.064369	0.776887	0.999300	0.030743	9304.17
20	0.145877	0.481201	0.068024	0.253185	2.173736	0.995036	1.064264	0.808039	0.999531	0.034330	9611.83
21	0.157947	0.499853	0.077503	0.261423	2.072092	0.995081	1.064135	0.837076	0.999680	0.038158	9924.57
22	0.170621	0.517873	0.087828	0.269833	1.978870	0.995129	1.063978	0.863787	0.999778	0.042231	10243.86
23	0.183929	0.535264	0.099032	0.278437	1.893275	0.995180	1.063789	0.887994	0.999844	0.046558	10570.48
24	0.197902	0.552039	0.111137	0.287229	1.814733	0.995235	1.063564	0.909559	0.999888	0.051145	10904.26
25	0.212574	0.568221	0.124156	0.296175	1.742855	0.995294	1.063300	0.928407	0.999919	0.055998	11243.89
26	0.227980	0.583843	0.138082	0.305207	1.677393	0.995356	1.062992	0.944532	0.999940	0.061118	11586.75
27	0.244155	0.598950	0.152891	0.314220	1.618194	0.995423	1.062639	0.958004	0.999955	0.066501	11928.94
28	0.261140	0.613597	0.168538	0.323083	1.565160	0.995494	1.062235	0.968973	0.999966	0.072142	12265.41
29	0.278974	0.627850	0.184961	0.331641	1.518198	0.995570	1.061781	0.977655	0.999973	0.078034	12590.29
30	0.297699	0.641786	0.202088	0.339729	1.477185	0.995651	1.061273	0.984321	0.999978	0.084168	12897.37
31	0.317361	0.655490	0.219841	0.347193	1.441940	0.995737	1.060711	0.989273	0.999982	0.090536	13180.73
32	0.338006	0.669053	0.238152	0.353901	1.412201	0.995829	1.060094	0.992819	0.999985	0.097136	13435.39
33	0.359683	0.682575	0.256570	0.359760	1.387618	0.995928	1.059418	0.995255	0.999987	0.103966	13657.81
34	0.382443	0.696158	0.276275	0.364726	1.367755	0.996035	1.058682	0.996841	0.999988	0.111040	13846.34
35	0.406342	0.709908	0.296085	0.368808	1.352100	0.996149	1.057881	0.997791	0.999989	0.118378	14001.29
36	0.431436	0.723930	0.316460	0.372066	1.340077	0.996273	1.057005	0.998271	0.999990	0.126013	14124.97
37	0.457785	0.738327	0.337506	0.374604	1.331071	0.996406	1.056046	0.998391	0.999990	0.133985	14221.32
38	0.485451	0.753196	0.359374	0.376562	1.324439	0.996551	1.054987	0.998208	0.999991	0.142350	14295.68
39	0.514500	0.768627	0.382257	0.378107	1.319534	0.996709	1.053809	0.997727	0.999991	0.151170	14354.34
40	0.545002	0.784699	0.406389	0.379424	1.315711	0.996881	1.052489	0.996897	0.999991	0.160520	14404.33
41	0.577029	0.801479	0.432048	0.380719	1.312324	0.997068	1.050993	0.995595	0.999992	0.170488	14453.50
42	0.610657	0.819019	0.459572	0.382231	1.308697	0.997272	1.049282	0.993599	0.999992	0.181176	14510.89
43	0.645966	0.837357	0.489384	0.384262	1.304062	0.997495	1.047303	0.990537	0.999992	0.192714	14587.99
44	0.683041	0.856509	0.522067	0.387241	1.297431	0.997739	1.044980	0.985780	0.999993	0.205275	14701.08
45	0.721970	0.876466	0.558495	0.391851	1.287380	0.998005	1.042201	0.978240	0.999993	0.219108	14876.09
46	0.762845	0.897171	0.600120	0.399294	1.271638	0.998293	1.038778	0.965931	0.999994	0.234625	15158.65
47	0.805764	0.918500	0.649600	0.411920	1.246322	0.998606	1.034361	0.944943	0.999995	0.252582	15637.99
48	0.850829	0.940190	0.712337	0.434937	1.204448	0.998939	1.028224	0.906630	0.999997	0.274480	16511.80
49	0.898148	0.961722	0.800273	0.482026	1.133606	0.999288	1.018843	0.828441	0.999998	0.303756	18299.47
50	0.947832	0.982097	0.935987	0.598451	1.020715	0.999640	1.007360	0.636124	0.999999	0.349042	22719.37
51	1.000000	1.000000	1.003332	1.000000	1.000000	1.000000	1.000000	0.0	1.000000	0.360816	37963.65

K =1, I = 4, S = 0.600, NITER = 1, DIFI = 1.7140-01 1.4880-01 1.1920-01 6.8240 00
 K =1, I = 4, S = 0.600, NITER = 2, DIFI = 2.4190-01 7.3620-02 8.6620-02 8.2760-01
 K =1, I = 4, S = 0.600, NITER = 3, DIFI = 4.6200-02 3.3600-02 2.5730-02 2.2280-01
 K =1, I = 4, S = 0.600, NITER = 4, DIFI = 6.5600-03 1.0780-02 8.3460-03 6.4010-02
 K =1, I = 4, S = 0.600, NITER = 5, DIFI = 5.0320-04 1.5790-03 3.3380-03 2.9630-02
 K =1, I = 4, S = 0.600, NITER = 6, DIFI = 7.8470-04 4.3590-04 3.2150-04 6.5740-03

**** FREE FLIGHT 140B ORBITER ALT=245K FT. M=26.9 ALPHA=30, BINARY-GAS

S	X	R	YSH	YSHP	XSH	RSH	NO ITER	NITTOT	NTOT	I	K
0.600000	0.153125	0.576231	0.088778	-0.021844	0.071465	0.611063	6	50	50	4	1
DS	CF	HEAT	STAN	COF	CDP	CDTOT	PWALL	TWALL	PW/PO		
0.200000	0.020365	0.024787	0.051705	0.005592	1.578926	1.584518	0.714939	2460.000000	0.816393		
YSHP (S	YSHP (S+DS/2	NEW YSHP	ALPHA(S+DS/2	PHI(S+DS/2	KAPPA(S	KAPPA(S+DS/2					
0.000000	0.000000	-0.021844	1.114267	1.114267	0.398202	0.354594					
USH	VSH	TSH	RSH	PSH	VPG						
0.396758	-0.096824	0.281341	9.467410	0.752737	0.0						
9958.63	-2430.28	32261.11									
		17922.85									

100 K =1, I = 5, S = 0.800, NITER = 1, DIFI = 6.0700-02 9.2280-02 8.1950-02 1.8110 00
 K =1, I = 5, S = 0.800, NITER = 2, DIFI = 4.1880-02 1.8950-02 2.7700-02 6.6220-01
 K =1, I = 5, S = 0.800, NITER = 3, DIFI = 8.2500-03 6.6390-03 5.1270-03 3.9670-02
 K =1, I = 5, S = 0.800, NITER = 4, DIFI = 2.0780-03 1.0510-03 3.1840-03 3.8600-02
 K =1, I = 5, S = 0.800, NITER = 5, DIFI = 1.5270-04 2.6030-04 1.7670-04 6.5260-03

**** FREE FLIGHT 140B ORBITER ALT=245K FT. M=26.9 ALPHA=30, BINARY-GAS

S	X	R	YSH	YSHP	XSH	RSH	NO ITER	NITTOT	NTOT	I	K
0.800000	0.241411	0.755630	0.090974	0.043798	0.161130	0.798420	5	55	55	5	1
DS	CF	HEAT	STAN	COF	CDP	CDTOT	PWALL	TWALL	PW/PO		
0.200000	0.021500	0.022818	0.047597	0.007541	1.486205	1.493747	0.647636	2460.000000	0.739540		
YSHP (S	YSHP (S+DS/2	NEW YSHP	ALPHA(S+DS/2	PHI(S+DS/2	KAPPA(S	KAPPA(S+DS/2					
-0.000000	0.000000	0.043798	1.033441	1.033441	0.309931	0.278565					
USH	VSH	TSH	RSH	PSH	VPG						
0.476350	-0.092866	0.258557	9.457766	0.691116	0.0						
11956.40	-2330.94	29648.52									
		16471.41									

N	Y/YSH	U/USH	V/VSH	T/TSH	R/RSR	P/PSH(APPR)	P/PSH	CA	CAEQ	XM	T DEG R
1	0.0	0.0	0.0	0.090044	10.267920	0.923055	1.001704	0.0	0.000003	0.0	2463.45
2	0.004777	0.038203	0.000064	0.112695	7.726415	0.923058	1.001707	0.060766	0.000249	0.225582	3083.16
3	0.009792	0.073332	0.000290	0.131926	6.264774	0.923070	1.001719	0.1116635	0.003323	0.392782	3609.29
4	0.015059	0.106442	0.000704	0.148902	5.296664	0.923095	1.001744	0.169391	0.018828	0.526678	4073.71
5	0.020588	0.138091	0.001327	0.164228	4.600746	0.923138	1.001786	0.219994	0.0365467	0.638621	4493.03
6	0.026394	0.168605	0.002185	0.178272	4.072950	0.923200	1.001846	0.269009	0.164526	0.734689	4877.25
7	0.032491	0.198134	0.003301	0.191271	3.657324	0.923283	1.001925	0.316786	0.323319	0.818604	5232.87
8	0.038892	0.226951	0.004702	0.203387	3.320843	0.923388	1.002026	0.363538	0.518159	0.892756	5564.34
9	0.045614	0.254976	0.006414	0.214738	3.042615	0.923518	1.002150	0.409392	0.700111	0.958919	5874.89
10	0.052671	0.282299	0.008465	0.225416	2.808680	0.923673	1.002296	0.454407	0.831198	1.018385	6167.02
11	0.060681	0.308929	0.010884	0.235498	2.609282	0.923857	1.002468	0.498591	0.908798	1.072045	6442.85
12	0.067862	0.334859	0.013701	0.245058	2.437350	0.924069	1.002665	0.541902	0.950272	1.120594	6704.39
13	0.076032	0.360067	0.016947	0.254168	2.287604	0.924312	1.002888	0.584253	0.971929	1.164633	6953.63
14	0.084610	0.384522	0.020654	0.262906	2.155999	0.924588	1.003138	0.625516	0.983476	1.204400	7192.70
15	0.093617	0.408183	0.024858	0.271355	2.039379	0.924898	1.003414	0.665525	0.989874	1.240207	7423.84
16	0.103075	0.431012	0.029596	0.279600	1.935253	0.925244	1.003718	0.704079	0.993574	1.272323	7649.41
17	0.113006	0.452966	0.034906	0.287728	1.841646	0.925626	1.004049	0.740952	0.995802	1.300995	7871.77
18	0.123433	0.474014	0.040829	0.295819	1.756998	0.926047	1.004407	0.775899	0.997191	1.326477	8093.15
19	0.134381	0.494129	0.047406	0.303946	1.680092	0.926508	1.004790	0.808671	0.998084	1.349174	8315.49
20	0.145877	0.513299	0.054679	0.312163	1.610001	0.927009	1.005198	0.839024	0.998672	1.369264	8540.28
21	0.157947	0.531531	0.062683	0.320499	1.546047	0.927551	1.005628	0.866737	0.999066	1.387096	8768.33
22	0.170621	0.548845	0.071452	0.328950	1.487766	0.928137	1.006080	0.891627	0.999334	1.403080	8999.54
23	0.183929	0.565284	0.081005	0.337473	1.434875	0.928766	1.006551	0.913567	0.999518	1.417684	9232.73
24	0.197902	0.580908	0.091351	0.345980	1.387241	0.929442	1.007041	0.932498	0.999645	1.431424	9465.46
25	0.212574	0.595757	0.102480	0.354335	1.344838	0.930166	1.007548	0.948446	0.999733	1.444929	9694.04
26	0.227980	0.610046	0.114365	0.362362	1.307702	0.930941	1.008072	0.961520	0.999794	1.458686	9913.65
27	0.244155	0.623763	0.126959	0.369857	1.275900	0.931770	1.008613	0.971917	0.999837	1.473224	10118.69
28	0.261140	0.637069	0.140203	0.376604	1.249434	0.932659	1.009174	0.979900	0.999867	1.489085	10303.27
29	0.278974	0.650089	0.154036	0.382405	1.228300	0.933613	1.009758	0.985784	0.999867	1.506754	10461.98
30	0.297699	0.662956	0.168402	0.387102	1.212362	0.934640	1.010368	0.989902	0.999901	1.526642	10590.50
31	0.317361	0.675801	0.183265	0.390603	1.201381	0.935747	1.011009	0.992579	0.999910	1.549069	10686.29
32	0.338036	0.688753	0.198621	0.392891	1.195006	0.936947	1.011686	0.994104	0.999915	1.574259	10748.88
33	0.359683	0.701936	0.214506	0.394028	1.192782	0.938250	1.012403	0.994710	0.999918	1.602341	10779.96
34	0.382443	0.715461	0.230996	0.394142	1.194173	0.939671	1.013166	0.994562	0.999918	1.633355	10783.11
35	0.406342	0.729423	0.248209	0.393416	1.198595	0.941224	1.013975	0.993754	0.999916	1.667287	10763.24
36	0.431436	0.743900	0.266293	0.392058	1.205451	0.942926	1.014833	0.992309	0.999913	1.704046	10726.08
37	0.457785	0.758948	0.285418	0.392083	1.214164	0.944798	1.015739	0.990180	0.999908	1.743527	10677.53
38	0.485451	0.774600	0.305770	0.388301	1.224206	0.946859	1.016690	0.987254	0.999903	1.785605	10623.30
39	0.514500	0.790865	0.327538	0.386308	1.235104	0.949132	1.017682	0.983353	0.999897	1.830152	10568.77
40	0.545002	0.807730	0.350921	0.384491	1.246422	0.951642	1.018706	0.978229	0.999891	1.877633	10519.07
41	0.577029	0.825161	0.376134	0.383045	1.257732	0.954415	1.019750	0.971557	0.999886	1.926093	10479.50
42	0.610657	0.843101	0.403428	0.382190	1.268552	0.957478	1.020796	0.962921	0.999883	1.977130	10456.11
43	0.645966	0.861471	0.433124	0.382209	1.278272	0.960861	1.021816	0.951782	0.999882	2.029851	10456.63
44	0.683041	0.880166	0.465666	0.383495	1.286045	0.964591	1.022764	0.937430	0.999885	2.083814	10491.80
45	0.721970	0.899051	0.501727	0.386643	1.290601	0.968694	1.023562	0.918871	0.999893	2.138323	10577.95
46	0.762845	0.917951	0.542417	0.392653	1.289906	0.973188	1.024073	0.894580	0.999908	2.192255	10742.35
47	0.805764	0.936643	0.585768	0.403395	1.280431	0.978080	1.024018	0.861893	0.999929	2.243710	11036.25
48	0.850829	0.954823	0.648037	0.422976	1.255431	0.983344	1.022761	0.815262	0.999955	2.289098	11571.94
49	0.898148	0.972043	0.727746	0.462565	1.200636	0.988891	1.018596	0.740087	0.999979	2.320998	12655.05
50	0.947832	0.987544	0.858754	0.564260	1.086472	0.994491	1.010363	0.582548	0.999996	2.325834	15437.24
51	1.000000	1.000000	0.986765	1.000000	1.000000	1.000000	1.000000	0.0	1.000000	2.363807	27358.40

Listing of the Unit 6 Output Data for the 140B Orbiter 7-Species Sample Case

FREE FLIGHT 140B ORBITER ALT=245K FT. M=26.9 ALPHA=30, 7-SPECIES

INPUT

ALT= 245000.0000000000 ,BRAD= 2.360833000000000 ,CAINF= 0.0 ,CAT= 1.000000000000000 ,CAW=
 0.0 ,CCFAC= 0.0 ,CONVRG= 0.9999997913837432D-02,DS= 0.200000000000000 ,DSMAX=
 1.000000000000000 ,HANGLE= 10.00000000000000 ,PRNTCI= 0.0 ,RINF= 0.8672510279999999D-07,SEND=
 35.00000000000000 ,SIGM= 0.6999999880790710 ,SITEST= 0.9999999019782990D-04,SMALLT= 0.9999994290410541D-06,SSFAC=
 -1.000000000000000 ,SWFAC= -1.000000000000000 ,TB= 2460.000000000000 ,THINI= -1.000000000000000 ,TINF=
 361.4800000000000 ,UFAC= 0.500000000000000 ,UINF= 25100.00000000000 ,WVFAC= 0.250000000000000 ,XKETA=
 1.050000000000000 ,XLE= 1.399999618530273 ,XNS0= 0.1165999770164490 ,IE= 51, IEND= 6, IGFORM= 3,
 IUN= 19, JFAC= 1, KEND= 1, KPLTTP= C, KTVAL= 0, NAN= -2, NDATA= 1, NITMAX= 3,
 9999, NITMIN= 3, NITMNI= 3, NS= 6, NSI= 6, NSPRF= 0, NTSH= 20, NTTWA= 5
 5
 END

LJG RATES MATCH 6 SPECIE BLOTTNER-SANDIA

NR	REACTION			CRO	EXP(CRO)	CR1	CR2	DRO	EXP(DRO)	DR1	DR2
1	O2	M1	=O O M1	42.7302394	0.3610D 19	59400.0	-1.0	35.6407165	0.3010D 16	0.0	-0.5
2	N2	M2	=N N M2	39.7962718	0.1920D 18	113100.0	-0.5	36.9275392	0.1090D 17	0.0	-0.5
3	N2	N	=N N N	52.0799804	0.4150D 23	113100.0	-1.5	49.1958541	0.2320D 22	0.0	-1.5
4	NO	M3	=N O M3	47.4304680	0.3970D 21	75600.0	-1.5	46.0616522	0.1010D 21	0.0	-1.5
5	NO	O	=O2 N	21.8801470	0.3180D 10	19700.0	1.0	27.5933192	0.9630D 12	3600.0	0.5
6	N2	O	=NO N	31.8431487	0.6750D 14	37500.0	0.0	30.3390713	0.1500D 14	0.0	0.0
7	N	O	=NO+ EL	22.9238182	0.9030D 10	32400.0	0.5	44.3369034	0.1800D 20	0.0	-1.0

ALPHSB(7,10)

NR	ALSUB	NR	C	O2	NO	N	NO+	N2	M1	M2	M3	EL
1	1.0	1	0.	1.	0.	0.	0.	0.	1.	0.	0.	0.
2	1.0	2	0.	0.	0.	0.	0.	1.	0.	1.	0.	0.
3	1.0	3	0.	0.	0.	1.	0.	1.	0.	0.	0.	0.
4	1.0	4	0.	0.	1.	0.	0.	0.	0.	0.	1.	0.
5	1.0	5	1.	0.	1.	0.	0.	0.	0.	0.	0.	0.
6	1.0	6	1.	0.	0.	0.	0.	1.	0.	0.	0.	0.
7	1.0	7	1.	0.	0.	1.	0.	0.	0.	0.	0.	0.

		BETASB(7,10)										
NR	BETSUB	NR	O	C2	NO	N	NO+	N2	M1	M2	M3	EL
1	2.0	1	2.	0.	0.	0.	0.	0.	1.	0.	0.	0.
2	2.0	2	0.	0.	0.	2.	0.	0.	0.	1.	0.	0.
3	2.0	3	0.	0.	0.	3.	0.	0.	0.	0.	0.	0.
4	2.0	4	1.	0.	0.	1.	0.	0.	0.	0.	1.	0.
5	1.0	5	0.	1.	0.	1.	0.	0.	0.	0.	0.	0.
6	1.0	6	0.	0.	1.	1.	0.	0.	0.	0.	0.	0.
7	1.0	7	0.	0.	0.	0.	1.	0.	0.	0.	0.	1.

ZSUB(4, 6)

	O	O2	NO	N	NO+	N2
M1	25.0	9.0	1.0	1.0	0.0	2.0
M2	1.0	1.0	1.0	0.0	0.0	2.5
M3	20.0	1.0	20.0	20.0	0.0	1.0
EL	0.0	0.0	0.0	0.0	1.0	0.0

		GAMMPL(7, 6)					
1	2.	0.	0.	0.	0.	0.	
2	0.	0.	0.	2.	0.	0.	
3	0.	0.	0.	2.	0.	0.	
4	1.	0.	0.	1.	0.	0.	
5	0.	1.	0.	1.	0.	0.	
6	0.	0.	1.	1.	0.	0.	
7	0.	0.	0.	0.	1.	0.	

		GAMMMI(7, 6)					
1	0.	1.	0.	0.	0.	0.	
2	0.	0.	0.	0.	0.	1.	
3	0.	0.	0.	0.	0.	1.	
4	0.	0.	1.	0.	0.	0.	
5	1.	0.	1.	0.	0.	0.	
6	1.	0.	0.	0.	0.	1.	
7	1.	0.	0.	1.	0.	0.	

VSREF = 0.23353999D-04

VSINF = 0.35867911D-06

```

K =1, I = 1, S = 0.0 , NITER = 1, DIFI = 3.6630 01 5.0110 00 0.0      1.0000 00 0.0      0.0      0.0      7.5250-01
K =1, I = 1, S = 0.0 , NITER = 2, DIFI = 6.1270-01 2.7390-01 8.8460-01 6.0910 02 8.6420 16 3.8440 17 7.5870 35 1.4220 00
K =1, I = 1, S = 0.0 , NITER = 3, DIFI = 4.1050-01 9.8700-01 2.6430 01 3.2780 03 1.7720 00 9.6990-01 9.9150-01 1.3650 02
K =1, I = 1, S = 0.0 , NITER = 4, DIFI = 3.1070 00 7.2670 00 9.5070-01 1.4680 02 9.0060 02 4.8720 00 1.5410 01 2.0060 01
K =1, I = 1, S = 0.0 , NITER = 5, DIFI = 2.1030-01 3.6710 01 1.0170 00 1.0970 38 2.4960 01 4.6940 02 2.7640 16 7.5470 00
K =1, I = 1, S = 0.0 , NITER = 6, DIFI = 3.9820-01 3.6580 00 2.8950 01 4.8310 00 4.4420-01 4.9570 10 2.7680 00 1.2140 00
K =1, I = 1, S = 0.0 , NITER = 7, DIFI = 4.0680-01 4.7610 00 2.3910 00 1.0000 40 7.5150 01 1.9050 00 1.5310 09 6.6900 00
K =1, I = 1, S = 0.0 , NITER = 8, DIFI = 2.5620-01 7.6930-01 1.0000 00 1.0000 00 7.7440 01 4.1400 02 1.0000 00 5.0280 00
K =1, I = 1, S = 0.0 , NITER = 9, DIFI = 5.5010-01 8.2950-01 3.8910 39 7.2130 38 1.0000 00 1.0000 00 3.9290 03 6.1240 01
K =1, I = 1, S = 0.0 , NITER = 10, DIFI = 9.7070-01 4.7510-01 9.9460-01 1.0000 40 5.6420 05 7.7730 02 2.4050 00 3.5280 00
K =1, I = 1, S = 0.0 , NITER = 11, DIFI = 2.0730-01 1.8650 00 4.0820 02 1.0000 00 7.5270-01 9.9830-01 8.8100 02 3.2280 00
K =1, I = 1, S = 0.0 , NITER = 12, DIFI = 4.1040-01 4.4470-01 9.6290-01 1.0000 40 9.8610-01 4.8100 01 9.4410-01 2.3750 01
K =1, I = 1, S = 0.0 , NITER = 13, DIFI = 2.2810-01 2.8190 01 2.4470 01 9.8520-01 4.8780 01 1.1830 03 4.4220 01 5.5260 01
K =1, I = 1, S = 0.0 , NITER = 14, DIFI = 7.4850-01 3.5630-01 8.6720-01 2.2520 01 9.9380-01 1.6410 01 3.5940 00 2.0830 01
K =1, I = 1, S = 0.0 , NITER = 15, DIFI = 2.1360-01 3.2950-01 2.6830-01 8.8850-01 2.3560 01 5.9630-01 7.5570-01 8.1770-01
K =1, I = 1, S = 0.0 , NITER = 16, DIFI = 2.1520-01 9.8550-02 2.0020-01 2.4420 00 6.9860-01 8.0640-01 5.1490-01 3.3820-01
K =1, I = 1, S = 0.0 , NITER = 17, DIFI = 4.4750-02 4.8660-01 5.0620-01 5.0420-01 4.0660-01 1.9560 00 6.9290-01 2.2240-01
K =1, I = 1, S = 0.0 , NITER = 18, DIFI = 1.3020-01 9.7900-02 2.3690-01 3.0090-01 9.4140-01 7.7610-01 7.6320-01 4.7910-02
K =1, I = 1, S = 0.0 , NITER = 19, DIFI = 3.1520-02 5.8410-02 2.1340-01 2.7290-01 1.1650-01 2.4550-01 3.6330-01 7.0780-02
K =1, I = 1, S = 0.0 , NITER = 20, DIFI = 3.3420-02 7.2380-02 1.0030-01 5.3110-02 2.1240-01 2.0480-01 3.1080-01 2.6080-02
K =1, I = 1, S = 0.0 , NITER = 21, DIFI = 2.1920-02 3.4530-02 3.7340-02 1.4880-01 1.2870-01 1.8820-01 8.5080-02 3.7400-02
K =1, I = 1, S = 0.0 , NITER = 22, DIFI = 9.1070-03 3.4430-02 4.8260-02 1.1360-01 7.9140-02 1.0110-01 8.1210-02 2.0830-02
K =1, I = 1, S = 0.0 , NITER = 23, DIFI = 1.3270-02 2.7100-02 5.1500-02 5.3750-02 7.9300-02 4.2590-02 2.6800-02 1.3990-02
K =1, I = 1, S = 0.0 , NITER = 24, DIFI = 6.8720-03 4.9610-03 1.6860-02 6.0820-02 2.0980-02 8.7270-02 3.9610-02 7.9450-03
K =1, I = 1, S = 0.0 , NITER = 25, DIFI = 1.6630-03 7.3580-03 2.8770-02 5.2740-02 3.8610-02 6.9220-03 1.3760-02 6.1540-03
K =1, I = 1, S = 0.0 , NITER = 26, DIFI = 2.4960-03 2.8850-03 2.2340-03 1.7190-02 2.4780-02 1.2420-02 9.4600-03 1.6400-03
K =1, I = 1, S = 0.0 , NITER = 27, DIFI = 4.2920-04 1.6150-03 5.9550-03 2.1150-02 9.4510-03 2.0880-02 6.7000-03 1.9830-03
K =1, I = 1, S = 0.0 , NITER = 28, DIFI = 5.5420-04 2.6500-03 4.4740-03 2.0490-02 8.7070-03 1.3970-03 9.2380-03 1.7830-03
K =1, I = 1, S = 0.0 , NITER = 29, DIFI = 1.0300-03 8.7780-04 2.9190-03 1.0960-02 9.1920-03 3.8990-03 3.0690-03 9.9560-04
K =1, I = 1, S = 0.0 , NITER = 30, DIFI = 1.2350-04 5.6220-04 2.4560-03 9.6940-03 4.5430-03 7.4810-03 1.0030-03 5.4960-04

```

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UINF      PINF      TINF      CAINF      TB      BRAD      PR      LE      YSH      ALT
0.2510 05  0.539380-01 0.361480 03  0.0      0.24600 04  0.23610 01  0.700 00  0.140 01  0.45420-01 0.2450 06

```

```

THIN SHOCK LAYER NO WALL SLIP NO SHOCK SLIP CAT WALL NO STEPS IN Y= 51 NO STEPS IN S= 6 S STEP SIZE=0.200

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```

TW/TS      EPS      REYINF      REYSH      TREF      UREF      RREF      PREF      ITER
0.0742  0.0674  0.14330 05  0.65940 03  0.10450 06  0.25100 05  0.86730-07 0.54640 02  1

```

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**** FREE FLIGHT 140B ORBITER ALT=245K FT. M=26.9 ALPHA=30, 7-SPECIES

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S      X      R      YSH      YSHP      XSH      RSH      NO ITER      NITTOT      NTOT      I      K
0.0    0.0    0.0    0.045418 0.0      -0.045418 0.0      30      30      30      1      1

```

```

DS      CF      HEAT      STAN      CDF      CDP      CDTOT      PWALL      TWALL      PW/PO
0.200000 0.0    0.039920 0.083507 0.0      1.762960 1.762960 0.881480 2460.000000 1.000000

```

```

YSHP ( S  YSHP ( S+DS/2  NEW YSHP  ALPHA(S+DS/2  PHI(S+DS/2  KAPPA(S  KAPPA(S+DS/2
0.0      0.000000      0.0      1.444297  1.444297  1.000000  0.977685

```

```

USH      VSH      TSH      PSH      PSH      VPG
0.0      -0.099716  0.312089  9.948308  0.886151  0.0
0.0      -2502.88  32616.88  18120.50

```

N	Y/YSH	U/USH	V/VSH	T/TSH	R/RSR	P/PSH(APPR)	P/PSH	CA	CAEQ	XM	T DEG R
1	0.0	0.0	0.0	0.075421	13.189015	0.994730	1.058007	0.0	0.000002	0.0	2460.00
2	0.004777	0.040336	0.000110	0.114092	8.460444	0.994730	1.058007	0.030433	0.004301	0.000105	3721.33
3	0.009792	0.073752	0.000503	0.145062	6.492926	0.994731	1.058008	0.055497	0.094627	0.000425	4731.48
4	0.015059	0.103470	0.001185	0.171896	5.362561	0.994733	1.058010	0.077268	0.452639	0.000916	5606.72
5	0.020588	0.130812	0.002165	0.195933	4.613281	0.994736	1.058012	0.096576	0.835184	0.001557	6390.74
6	0.026394	0.156480	0.003455	0.217827	4.074532	0.994740	1.058014	0.113843	0.962140	0.002340	7104.84
7	0.032491	0.180901	0.005065	0.237943	3.666306	0.994745	1.058016	0.129321	0.989461	0.003259	7760.97
8	0.038892	0.204355	0.007011	0.256510	3.345440	0.994752	1.058018	0.143174	0.996269	0.004315	8366.56
9	0.045614	0.227037	0.009306	0.273683	3.086328	0.994760	1.058020	0.155523	0.998400	0.005510	8926.67
10	0.052671	0.249086	0.011566	0.289577	2.872676	0.994769	1.058023	0.166468	0.999206	0.006847	9445.10
11	0.060081	0.270605	0.015008	0.304288	2.693534	0.994780	1.058018	0.176099	0.999558	0.008332	9924.94
12	0.067862	0.291667	0.018449	0.317902	2.541233	0.994793	1.058014	0.184506	0.999731	0.009973	10368.97
13	0.076032	0.312327	0.022308	0.330497	2.410216	0.994807	1.058007	0.191780	0.999825	0.011776	10779.78
14	0.084610	0.332623	0.026608	0.342149	2.296351	0.994824	1.057996	0.198016	0.999879	0.013750	11159.83
15	0.093617	0.352580	0.031369	0.352931	2.196499	0.994843	1.057980	0.203313	0.999912	0.015906	11511.50
16	0.103075	0.372215	0.036616	0.362914	2.108229	0.994864	1.057958	0.207770	0.999934	0.018253	11837.14
17	0.113006	0.391534	0.042376	0.372170	2.029630	0.994888	1.057930	0.211485	0.999948	0.020803	12139.02
18	0.123433	0.410539	0.048675	0.380765	1.959184	0.994914	1.057892	0.214553	0.999959	0.023567	12419.36
19	0.134381	0.429229	0.055543	0.388765	1.895677	0.994943	1.057845	0.217063	0.999966	0.026558	12680.31
20	0.145877	0.447597	0.063011	0.396234	1.838129	0.994976	1.057785	0.219097	0.999972	0.029787	12923.92
21	0.157947	0.465639	0.071110	0.403230	1.785750	0.995012	1.057711	0.220728	0.999976	0.033267	13152.11
22	0.170621	0.483350	0.079873	0.409810	1.737895	0.995051	1.057621	0.222023	0.999979	0.037011	13366.72
23	0.183929	0.500729	0.089333	0.416026	1.694042	0.995095	1.057511	0.223037	0.999982	0.041030	13569.47
24	0.197902	0.517779	0.099525	0.421928	1.653760	0.995143	1.057379	0.223819	0.999984	0.045337	13761.98
25	0.212574	0.534510	0.110481	0.427563	1.616696	0.995195	1.057222	0.224408	0.999986	0.049948	13945.77
26	0.227980	0.550938	0.122239	0.432975	1.582557	0.995252	1.057035	0.224837	0.999987	0.054878	14122.29
27	0.244155	0.567091	0.134833	0.438207	1.551090	0.995314	1.056814	0.225133	0.999989	0.060140	14292.94
28	0.261140	0.583005	0.148300	0.443302	1.522077	0.995382	1.056555	0.225315	0.999990	0.065750	14459.12
29	0.278974	0.598725	0.162681	0.448302	1.495321	0.995455	1.056252	0.225399	0.999991	0.071723	14622.21
30	0.297699	0.614308	0.178019	0.453252	1.470634	0.995535	1.055903	0.225396	0.999991	0.078074	14783.68
31	0.317361	0.629817	0.194364	0.458200	1.447832	0.995622	1.055491	0.225313	0.999992	0.084815	14945.07
32	0.338006	0.645322	0.211773	0.463197	1.426728	0.995717	1.055018	0.225153	0.999993	0.091978	15108.06
33	0.359683	0.660900	0.230313	0.468300	1.407123	0.995819	1.054472	0.224917	0.999993	0.099590	15274.47
34	0.382443	0.676626	0.250066	0.473570	1.388805	0.995930	1.053843	0.224602	0.999994	0.107680	15446.38
35	0.406342	0.692578	0.271129	0.479081	1.371540	0.996051	1.053118	0.224202	0.999994	0.116285	15626.14
36	0.431436	0.708826	0.293623	0.484917	1.355073	0.996182	1.052282	0.223708	0.999995	0.125450	15816.49
37	0.457785	0.725437	0.317693	0.491178	1.339125	0.996324	1.051317	0.223107	0.999995	0.135228	16020.69
38	0.485451	0.742468	0.343515	0.497984	1.323388	0.996478	1.050201	0.222381	0.999996	0.145686	16242.70
39	0.514500	0.759963	0.371303	0.505487	1.307529	0.996645	1.048909	0.221505	0.999996	0.156916	16487.41
40	0.544502	0.777958	0.401320	0.513877	1.291181	0.996827	1.047407	0.220446	0.999997	0.168987	16761.06
41	0.577029	0.796473	0.433886	0.523406	1.273934	0.997024	1.045654	0.219157	0.999997	0.182012	17071.87
42	0.610657	0.815513	0.469403	0.534416	1.255322	0.997238	1.043598	0.217573	0.999997	0.196132	17430.99
43	0.645966	0.835067	0.508383	0.547389	1.234802	0.997469	1.041175	0.215598	0.999998	0.211493	17854.11
44	0.683041	0.855103	0.551495	0.563020	1.211718	0.997718	1.038295	0.213082	0.999998	0.228411	18363.97
45	0.721970	0.875565	0.599633	0.582356	1.185283	0.997987	1.034843	0.209770	0.999998	0.247303	18994.65
46	0.762845	0.896363	0.654006	0.607020	1.154570	0.998275	1.030661	0.205175	0.999999	0.268823	19799.10
47	0.805764	0.917370	0.716194	0.639622	1.118643	0.998583	1.025543	0.198253	0.999999	0.293901	20862.47
48	0.850829	0.938408	0.787942	0.684511	1.077089	0.998909	1.019271	0.186521	0.999999	0.324374	22326.61
49	0.898148	0.959265	0.869587	0.749118	1.031931	0.999252	1.011863	0.163683	1.000000	0.363474	24433.90
50	0.947832	0.979756	0.953054	0.846281	0.993803	0.999612	1.004587	0.113569	1.000000	0.413661	27603.07
51	1.000000	1.000000	0.999398	1.000000	1.000000	1.000000	1.000000	0.0	1.000000	0.457174	32616.88

N	Y/RN	O	O2	NC	N	NO+	N2	E-/CC	Y IN	Y CM
1	0.0	0.0	0.23456D 00	0.0	0.0	0.0	0.76544D 00	0.0	0.0	0.0
2	0.00022	0.30433D-01	0.19743D 00	0.12735D-01	0.28942D-02	0.35064D-04	0.75648D 00	0.26482D 13	0.00615	0.01561
3	0.00044	0.55497D-01	0.16711D 00	0.22735D-01	0.57487D-02	0.65474D-04	0.74885D 00	0.37949D 13	0.01260	0.03200
4	0.00068	0.77268D-01	0.14115D 00	0.30713D-01	0.89935D-02	0.94327D-04	0.74178D 00	0.45155D 13	0.01938	0.04921
5	0.00094	0.96576D-01	0.11856D 00	0.36971D-01	0.12840D-01	0.12292D-03	0.73493D 00	0.50621D 13	0.02649	0.06729
6	0.00120	0.11384D 00	0.98833D-01	0.41692D-01	0.17417D-01	0.15199D-03	0.72806D 00	0.55283D 13	0.03396	0.08626
7	0.00148	0.12932D 00	0.81630D-01	0.45021D-01	0.22809D-01	0.18204D-03	0.72104D 00	0.59579D 13	0.04181	0.10619
8	0.00177	0.14317D 00	0.66718D-01	0.47091D-01	0.29072D-01	0.21347D-03	0.71373D 00	0.63750D 13	0.05004	0.12711
9	0.00207	0.15552D 00	0.53904D-01	0.48037D-01	0.36235D-01	0.24660D-03	0.70605D 00	0.67941D 13	0.05869	0.14908
10	0.00239	0.16647D 00	0.43014D-01	0.48000D-01	0.44304D-01	0.28173D-03	0.69793D 00	0.72246D 13	0.06777	0.17214
11	0.00273	0.17610D 00	0.33876D-01	0.47130D-01	0.53266D-01	0.31909D-03	0.68931D 00	0.76725D 13	0.07731	0.19636
12	0.00308	0.18451D 00	0.26318D-01	0.45580D-01	0.63086D-01	0.35890D-03	0.68015D 00	0.81418D 13	0.08732	0.22179
13	0.00345	0.19178D 00	0.20165D-01	0.43506D-01	0.73712D-01	0.40131D-03	0.67044D 00	0.86344D 13	0.09783	0.24849
14	0.00384	0.19802D 00	0.15240D-01	0.41062D-01	0.85080D-01	0.44642D-03	0.66016D 00	0.91512D 13	0.10887	0.27652
15	0.00425	0.20331D 00	0.11367D-01	0.38390D-01	0.97108D-01	0.49427D-03	0.64933D 00	0.96915D 13	0.12046	0.30596
16	0.00468	0.20777D 00	0.83772D-02	0.35620D-01	0.10971D 00	0.54485D-03	0.63798D 00	0.10254D 14	0.13263	0.33687
17	0.00513	0.21149D 00	0.61131D-02	0.32865D-01	0.12277D 00	0.59806D-03	0.62616D 00	0.10836D 14	0.14540	0.36933
18	0.00561	0.21455D 00	0.44313D-02	0.30214D-01	0.13621D 00	0.65378D-03	0.61394D 00	0.11434D 14	0.15882	0.40340
19	0.00610	0.21706D 00	0.32058D-02	0.27737D-01	0.14989D 00	0.71179D-03	0.60139D 00	0.12045D 14	0.17291	0.43919
20	0.00663	0.21910D 00	0.23294D-02	0.25481D-01	0.16371D 00	0.77183D-03	0.58861D 00	0.12665D 14	0.18770	0.47676
21	0.00717	0.22273D 00	0.17138D-02	0.23474D-01	0.17755D 00	0.83361D-03	0.57570D 00	0.13289D 14	0.20323	0.51621
22	0.00775	0.22202D 00	0.12883D-02	0.21728D-01	0.19127D 00	0.89678D-03	0.56279D 00	0.13913D 14	0.21954	0.55763
23	0.00835	0.22304D 00	0.99837D-03	0.20239D-01	0.20476D 00	0.96097D-03	0.55001D 00	0.14532D 14	0.23666	0.60112
24	0.00899	0.22382D 00	0.80312D-03	0.18997D-01	0.21788D 00	0.10258D-02	0.53748D 00	0.15143D 14	0.25464	0.64679
25	0.00965	0.22441D 00	0.67280D-03	0.17983D-01	0.23050D 00	0.10908D-02	0.52535D 00	0.15743D 14	0.27352	0.69474
26	0.01035	0.22484D 00	0.58650D-03	0.17179D-01	0.24250D 00	0.11557D-02	0.51374D 00	0.16327D 14	0.29334	0.74509
27	0.01109	0.22513D 00	0.52992D-03	0.16563D-01	0.25375D 00	0.12201D-02	0.50281D 00	0.16894D 14	0.31415	0.79795
28	0.01186	0.22531D 00	0.49360D-03	0.16118D-01	0.26412D 00	0.12836D-02	0.49267D 00	0.17440D 14	0.33601	0.85346
29	0.01267	0.22540D 00	0.47148D-03	0.15828D-01	0.27351D 00	0.13458D-02	0.48344D 00	0.17964D 14	0.35896	0.91175
30	0.01352	0.22540D 00	0.45985D-03	0.15683D-01	0.28182D 00	0.14065D-02	0.47524D 00	0.18465D 14	0.38305	0.97295
31	0.01441	0.22531D 00	0.45654D-03	0.15676D-01	0.28894D 00	0.14655D-02	0.46815D 00	0.18941D 14	0.40835	1.03720
32	0.01535	0.22515D 00	0.46047D-03	0.15804D-01	0.29548D 00	0.15224D-02	0.46225D 00	0.19390D 14	0.43491	1.10468
33	0.01634	0.22492D 00	0.47124D-03	0.16071D-01	0.29939D 00	0.15771D-02	0.45758D 00	0.19810D 14	0.46280	1.17552
34	0.01737	0.22460D 00	0.48904D-03	0.16482D-01	0.30263D 00	0.16292D-02	0.45416D 00	0.20199D 14	0.49209	1.24991
35	0.01846	0.22420D 00	0.51451D-03	0.17050D-01	0.30454D 00	0.16785D-02	0.45201D 00	0.20551D 14	0.52284	1.32801
36	0.01960	0.22371D 00	0.54876D-03	0.17790D-01	0.30513D 00	0.17245D-02	0.45110D 00	0.20860D 14	0.55513	1.41003
37	0.02079	0.22311D 00	0.59347D-03	0.18727D-01	0.30441D 00	0.17663D-02	0.45140D 00	0.21115D 14	0.58903	1.49614
38	0.02205	0.22238D 00	0.65115D-03	0.19889D-01	0.30242D 00	0.18028D-02	0.45286D 00	0.21298D 14	0.62463	1.58656
39	0.02337	0.22151D 00	0.72556D-03	0.21318D-01	0.29919D 00	0.18321D-02	0.45543D 00	0.21385D 14	0.66201	1.68150
40	0.02475	0.22045D 00	0.82264D-03	0.23068D-01	0.29471D 00	0.18516D-02	0.45910D 00	0.21341D 14	0.70125	1.78118
41	0.02621	0.21916D 00	0.95246D-03	0.25209D-01	0.28896D 00	0.18570D-02	0.46386D 00	0.21118D 14	0.74246	1.88585
42	0.02773	0.21757D 00	0.11337D-02	0.27835D-01	0.28183D 00	0.18429D-02	0.46978D 00	0.20652D 14	0.78573	1.99576
43	0.02934	0.21560D 00	0.14041D-02	0.31061D-01	0.27311D 00	0.18019D-02	0.47703D 00	0.19862D 14	0.83116	2.11116
44	0.03102	0.21308D 00	0.18481D-02	0.35017D-01	0.26242D 00	0.17246D-02	0.48591D 00	0.18654D 14	0.87887	2.23233
45	0.03279	0.20977D 00	0.26656D-02	0.39818D-01	0.24917D 00	0.16007D-02	0.49698D 00	0.16937D 14	0.92896	2.35955
46	0.03465	0.20518D 00	0.43556D-02	0.45448D-01	0.23237D 00	0.14205D-02	0.51123D 00	0.14640D 14	0.98155	2.49314
47	0.03660	0.19825D 00	0.81975D-02	0.51474D-01	0.21050D 00	0.11784D-02	0.53040D 00	0.11768D 14	1.03678	2.63341
48	0.03864	0.18652D 00	0.17506D-01	0.56329D-01	0.18118D 00	0.87902D-03	0.55759D 00	0.84517D 13	1.09476	2.78069
49	0.04079	0.16368D 00	0.40816D-01	0.55796D-01	0.14074D 00	0.54419D-03	0.59842D 00	0.50130D 13	1.15565	2.93534
50	0.04305	0.11357D 00	0.99144D-01	0.40730D-01	0.83563D-01	0.22320D-03	0.66277D 00	0.19801D 13	1.21957	3.09772
51	0.04542	0.0	0.23456D 00	0.0	0.0	0.0	0.76544D 00	0.0	1.28670	3.26822

K =1, I = 4, S = 0.600, NITER = 1, DIFI = 1.8220-01 7.8750-02 1.7910-01 3.4190-01 2.3510-01 2.8150-01 3.3390-01 2.5700-01
K =1, I = 4, S = 0.600, NITER = 2, DIFI = 2.3980-01 3.5720-02 1.3330-01 1.4000-01 1.8190-01 2.0680-01 3.6210-01 8.0530-02
K =1, I = 4, S = 0.600, NITER = 3, DIFI = 6.2770-02 6.2090-02 5.9960-02 1.0130-01 1.0130-01 1.4090-01 2.0440-01 2.9580-02
K =1, I = 4, S = 0.600, NITER = 4, DIFI = 1.2110-02 1.9460-02 1.5130-02 3.4690-02 3.9750-02 4.5890-02 2.7110-02 1.0890-02
K =1, I = 4, S = 0.600, NITER = 5, DIFI = 2.2530-03 3.8240-03 1.1370-02 7.9020-03 8.7700-03 1.4710-02 1.7860-02 7.9020-03
K =1, I = 4, S = 0.600, NITER = 6, DIFI = 1.5970-03 1.8520-03 2.5300-03 2.6490-03 4.1330-03 2.8860-03 8.4210-03 1.1580-03

**** FREE FLIGHT 140B ORBITER ALT=245K FT. M=26.9 ALPHA=30, 7-SPECIES

S	X	R	YSH	YSHP	XSH	RSH	NO ITER	NITTOT	NTOT	I	K
0.600000	0.153125	0.576231	0.096495	-0.019326	0.064367	0.614090	6	48	48	4	1
DS	CF	HEAT	STAN	CDF	CDP	CDTOT	PWALL	TWALL	PW/PO		
0.200000	0.020479	0.023084	0.048289	0.005478	1.584793	1.590271	0.715207	2460.000000	0.811371		
YSHP (S	YSHP (S+DS/2	NEW YSHP	ALPHA(S+DS/2	PHI(S+DS/2	KAPPA(S	KAPPA(S+DS/2					
0.000000	0.000000	-0.019326	1.114267	1.114267	0.398202	0.354594					
USH	VSH	TSH	RSH	PSH	VPG						
0.396758	-0.096763	0.278381	9.472317	0.752913	0.0						
9958.63	-2428.76	29094.02									
		16163.35									

K =1, I = 5, S = 0.800, NITER = 1, DIFI = 5.6710-02 6.6390-02 4.6490-02 1.8180-01 1.7630-01 1.2760-01 2.1770-01 5.9140-02
K =1, I = 5, S = 0.800, NITER = 2, DIFI = 6.4540-02 4.2360-02 6.1280-02 1.2630-01 9.6840-02 7.1380-02 1.5940-01 3.2630-02
K =1, I = 5, S = 0.800, NITER = 3, DIFI = 6.1530-03 6.7630-03 1.0090-02 2.8800-02 2.0580-02 2.8700-02 3.9090-02 3.2550-03
K =1, I = 5, S = 0.800, NITER = 4, DIFI = 1.3760-03 2.0730-03 7.9250-03 9.6890-03 8.7150-03 5.4500-03 1.9460-02 4.4350-03

**** FREE FLIGHT 140B ORBITER ALT=245K FT. M=26.9 ALPHA=30, 7-SPECIES

S	X	R	YSH	YSHP	XSH	RSH	NO ITER	NITTOT	NTOT	I	K
0.800000	0.241411	0.755630	0.101063	0.065006	0.152226	0.803166	4	52	52	5	1
DS	CF	HEAT	STAN	CDF	CDP	CDTOT	PWALL	TWALL	PW/PO		
0.200000	0.021277	0.021063	0.044060	0.007456	1.488738	1.496195	0.645542	2460.000000	0.732339		
YSHP (S	YSHP (S+DS/2	NEW YSHP	ALPHA(S+DS/2	PHI(S+DS/2	KAPPA(S	KAPPA(S+DS/2					
-0.000000	0.000000	0.065006	1.033441	1.033441	0.309931	0.278565					
USH	VSH	TSH	RSH	PSH	VPG						
0.476350	-0.095165	0.261554	9.228450	0.689214	0.0						
11956.40	-2388.64	27335.38									
		15186.33									

N	Y/YSH	U/USH	V/VSH	T/TSH	R/RSH	P/PSH(APPR)	P/PSH	CA	CAEQ	XM	T DEG R
1	0.0	0.0	0.0	0.095815	9.631821	0.921889	0.988605	0.0	0.000003	0.0	2462.14
2	0.004777	0.046909	0.000107	0.150547	5.907479	0.921893	0.988609	0.040516	0.009227	0.236835	3868.59
3	0.009792	0.085167	0.000492	0.192563	4.484113	0.921906	0.988622	0.073377	0.184018	0.378270	4948.27
4	0.015059	0.119027	0.001159	0.227991	3.691387	0.921932	0.988648	0.101812	0.666176	0.481614	5858.65
5	0.020588	0.150118	0.002117	0.258932	3.175753	0.921972	0.988688	0.126959	0.932329	0.564549	6653.75
6	0.026394	0.179278	0.003377	0.286353	2.810673	0.922026	0.988743	0.149329	0.984927	0.634993	7358.36
7	0.032491	0.207007	0.004951	0.310773	2.538118	0.922096	0.988812	0.169185	0.995381	0.697363	7985.89
8	0.038892	0.233623	0.006852	0.332522	2.327159	0.922184	0.988898	0.186690	0.998167	0.754226	8544.77
9	0.045614	0.259344	0.009093	0.351841	2.159540	0.922289	0.989002	0.201981	0.999119	0.807365	9041.21
10	0.052671	0.284316	0.011691	0.368937	2.023640	0.922415	0.989124	0.215199	0.999511	0.857905	9480.53
11	0.060081	0.308639	0.014661	0.384008	1.911628	0.922564	0.989265	0.226503	0.999698	0.906575	9867.81
12	0.067862	0.332374	0.018024	0.397249	1.817996	0.922736	0.989429	0.236076	0.999796	0.953856	10208.06
13	0.076032	0.355557	0.021800	0.408858	1.738735	0.922934	0.989615	0.244112	0.999853	1.000011	10506.36
14	0.084610	0.378200	0.026014	0.419029	1.670854	0.923162	0.989825	0.250806	0.999888	1.045155	10767.73
15	0.093617	0.400299	0.030694	0.427955	1.612084	0.923421	0.990062	0.256347	0.999912	1.089294	10997.11
16	0.103075	0.421834	0.035870	0.435820	1.560680	0.923714	0.990327	0.260903	0.999928	1.132409	11199.22
17	0.113006	0.442781	0.041574	0.442795	1.515299	0.924043	0.990620	0.264622	0.999939	1.174411	11378.44
18	0.123433	0.463107	0.047839	0.449033	1.474905	0.924413	0.990944	0.267625	0.999948	1.215201	11538.74
19	0.134381	0.482784	0.054700	0.454672	1.438703	0.924825	0.991299	0.270011	0.999954	1.254689	11683.65
20	0.145877	0.501787	0.062189	0.459830	1.406092	0.925282	0.991687	0.271854	0.999959	1.292814	11816.20
21	0.157947	0.520101	0.070341	0.464607	1.376619	0.925789	0.992107	0.273211	0.999964	1.329553	11938.95
22	0.170621	0.537724	0.079186	0.469085	1.349945	0.926346	0.992561	0.274122	0.999967	1.364932	12054.02
23	0.183929	0.554674	0.088754	0.473333	1.325823	0.926959	0.993050	0.274618	0.999970	1.399029	12163.17
24	0.197902	0.570988	0.099075	0.477406	1.304065	0.927631	0.993572	0.274721	0.999972	1.431984	12267.83
25	0.212574	0.586723	0.110176	0.481350	1.284531	0.928365	0.994130	0.274450	0.999975	1.463983	12369.19
26	0.227980	0.601956	0.122086	0.485206	1.267106	0.929165	0.994722	0.273818	0.999977	1.495256	12468.28
27	0.244155	0.616783	0.134833	0.489009	1.251688	0.930037	0.995351	0.272840	0.999978	1.526067	12565.99
28	0.261140	0.631313	0.148450	0.492790	1.238179	0.930986	0.996015	0.271532	0.999980	1.556705	12663.16
29	0.278974	0.645663	0.162976	0.496582	1.226472	0.932018	0.996717	0.269908	0.999981	1.587462	12760.61
30	0.297699	0.659954	0.178455	0.500419	1.216447	0.933140	0.997457	0.267987	0.999982	1.618617	12859.21
31	0.317361	0.674301	0.194942	0.504337	1.207966	0.934361	0.998236	0.265785	0.999984	1.650424	12959.87
32	0.338006	0.688809	0.212504	0.508375	1.200869	0.935690	0.999055	0.263319	0.999985	1.683090	13063.64
33	0.359683	0.703568	0.231218	0.512579	1.194976	0.937138	0.999914	0.260607	0.999986	1.716769	13171.67
34	0.382443	0.718652	0.251179	0.517000	1.190089	0.938715	1.000813	0.257662	0.999987	1.751552	13285.28
35	0.406342	0.734112	0.272494	0.521697	1.185994	0.940436	1.001751	0.254496	0.999988	1.787466	13405.97
36	0.431436	0.749979	0.295285	0.526736	1.182470	0.942315	1.002725	0.251116	0.999988	1.824436	13535.46
37	0.457785	0.766263	0.319689	0.532195	1.179293	0.944367	1.003730	0.247525	0.999989	1.862303	13675.74
38	0.485451	0.782955	0.345857	0.538165	1.176240	0.946609	1.004759	0.243720	0.999990	1.901038	13829.16
39	0.514500	0.800026	0.373960	0.544756	1.173087	0.949058	1.005800	0.239692	0.999991	1.940448	13998.53
40	0.545002	0.817431	0.404184	0.552104	1.169612	0.951733	1.006840	0.235424	0.999992	1.980300	14187.34
41	0.577029	0.835108	0.436747	0.560383	1.165575	0.954653	1.007855	0.230886	0.999993	2.020313	14400.08
42	0.610657	0.852577	0.471909	0.569826	1.160705	0.957837	1.008816	0.226035	0.999993	2.060163	14642.74
43	0.645966	0.870942	0.509994	0.580758	1.154667	0.961304	1.009680	0.220802	0.999994	2.099175	14923.67
44	0.683041	0.888891	0.551443	0.593659	1.147003	0.965070	1.010387	0.215084	0.999995	2.137136	15255.16
45	0.721970	0.906692	0.596881	0.609265	1.137058	0.969152	1.010844	0.208723	0.999996	2.174013	15565.20
46	0.762845	0.924196	0.647265	0.628788	1.123837	0.973556	1.010906	0.201468	0.999997	2.209711	16157.87
47	0.805764	0.941226	0.704142	0.654343	1.105797	0.978285	1.010337	0.192863	0.999997	2.245691	16814.57
48	0.850829	0.957576	0.770039	0.689872	1.080682	0.983323	1.008747	0.181783	0.999998	2.281208	17727.54
49	0.898148	0.972993	0.848632	0.743327	1.046004	0.988634	1.005639	0.164421	0.999999	2.324239	19101.17
50	0.947832	0.987189	0.940536	0.832190	1.004388	0.994169	1.001788	0.125308	0.999999	2.406573	21384.66
51	1.000000	1.000000	1.002465	1.000000	1.000000	1.000000	1.000000	0.0	1.000000	2.633335	25696.87

N	Y/RN	O	O2	NO	N	NO+	N2	E-/CC	Y IN	Y CM
1	C.0	0.0	0.23456D 00	0.0	0.0	0.0	0.76544D 00	0.0	0.0	0.0
2	0.00057	0.40516D-01	0.19136D 00	0.13313D-C1	0.13368D-02	0.24702D-04	0.75345D 00	0.11792D 13	0.01627	0.04131
3	0.00118	0.73377D-01	0.15671D 00	0.23489D-C1	0.29304D-02	0.46210D-04	0.74344D 00	0.16744D 13	0.03334	0.08470
4	0.00181	0.10181D 00	0.12733D 00	0.31359D-C1	0.51663D-02	0.67112D-04	0.73427D 00	0.20019D 13	0.05128	0.13024
5	0.00247	0.12696D 00	0.10208D 00	0.37179D-C1	0.82963D-02	0.88469D-04	0.72540D 00	0.22703D 13	0.07011	0.17807
6	0.00317	0.14933D 00	0.80462D-01	0.41080D-C1	0.12518D-01	0.11092D-03	0.71650D 00	0.25193D 13	0.08988	0.22829
7	0.00391	0.16918D 00	0.62187D-01	0.43183D-C1	0.17581D-01	0.13495D-03	0.70733D 00	0.27678D 13	0.11064	0.28102
8	0.00467	0.18669D 00	0.47030D-01	0.43655D-C1	0.24780D-01	0.16096D-03	0.69768D 00	0.30268D 13	0.13243	0.33638
9	0.00548	0.20198D 00	0.34749D-01	0.42721D-C1	0.32955D-01	0.18928D-03	0.68740D 00	0.33031D 13	0.15532	0.39452
10	0.00633	0.21520D 00	0.25061D-01	0.40662D-01	0.42487D-01	0.22019D-03	0.67637D 00	0.36007D 13	0.17935	0.45556
11	0.00722	0.22650D 00	0.17638D-01	0.37789D-C1	0.53302D-01	0.25385D-03	0.66451D 00	0.39213D 13	0.20459	0.51965
12	0.00816	0.23608D 00	0.12123D-01	0.34420D-C1	0.65285D-01	0.29032D-03	0.65180D 00	0.42650D 13	0.23108	0.58695
13	0.00914	0.24411D 00	0.81552D-02	0.30849D-01	0.78285D-01	0.32953D-03	0.63827D 00	0.46301D 13	0.25890	0.65761
14	0.01017	0.25081D 00	0.53909D-02	0.27321D-C1	0.92130D-01	0.37132D-03	0.62398D 00	0.50135D 13	0.28811	0.73181
15	0.01125	0.25635D 00	0.35253D-02	0.24022D-01	0.10663D 00	0.41538D-03	0.60906D 00	0.54111D 13	0.31878	0.80971
16	0.01239	0.26090D 00	0.23037D-02	0.21071D-C1	0.12160D 00	0.46133D-03	0.59366D 00	0.58180D 13	0.35099	0.89151
17	0.01358	0.26462D 00	0.15252D-02	0.18528D-01	0.13683D 00	0.50871D-03	0.57798D 00	0.62291D 13	0.38480	0.97740
18	0.01484	0.26763D 00	0.10399D-02	0.16401D-C1	0.15214D 00	0.55703D-03	0.56223D 00	0.66389D 13	0.42031	1.06759
19	0.01615	0.27001D 00	0.74173D-03	0.14666D-01	0.16733D 00	0.60577D-03	0.54665D 00	0.70425D 13	0.45759	1.16228
20	0.01753	0.27185D 00	0.55921D-03	0.13278D-C1	0.18221D 00	0.65439D-03	0.53145D 00	0.74354D 13	0.49674	1.26171
21	0.01898	0.27321D 00	0.44649D-C3	0.12185D-C1	0.19658D 00	0.70241D-03	0.51688D 00	0.78137D 13	0.53784	1.36611
22	0.02051	0.27412D 00	0.37534D-03	0.11334D-01	0.21027D 00	0.74934D-03	0.50315D 00	0.81742D 13	0.58100	1.47573
23	0.02211	0.27462D 00	0.32902D-03	0.10680D-C1	0.22308D 00	0.79476D-03	0.49050D 00	0.85148D 13	0.62631	1.59083
24	0.02379	0.27472D 00	0.29793D-03	0.10195D-C1	0.23485D 00	0.83827D-03	0.47911D 00	0.88336D 13	0.67389	1.71169
25	0.02555	0.27445D 00	0.27665D-03	0.98235D-C2	0.24541D 00	0.87956D-03	0.46916D 00	0.91298D 13	0.72385	1.83859
26	0.02740	0.27382D 00	0.26220D-03	0.95748D-02	0.25462D 00	0.91835D-03	0.46081D 00	0.94031D 13	0.77631	1.97183
27	0.02935	0.27264D 00	0.25292D-03	0.94270D-02	0.26235D 00	0.95430D-03	0.45417D 00	0.96537D 13	0.83139	2.11174
28	0.03139	0.27153D 00	0.24792D-03	0.93728D-C2	0.26852D 00	0.98768D-03	0.44934D 00	0.98821D 13	0.88923	2.25864
29	0.03353	0.26991D 00	0.24674D-03	0.94094D-02	0.27305D 00	0.10180D-02	0.44637D 00	0.10090D 14	0.94996	2.41289
30	0.03578	0.26799D 00	0.24918D-03	0.95367D-C2	0.27594D 00	0.10456D-02	0.44524D 00	0.10278D 14	1.01372	2.57485
31	0.03815	0.26578D 00	0.25526D-03	0.97570D-C2	0.27720D 00	0.10704D-02	0.44594D 00	0.10448D 14	1.08067	2.74490
32	0.04063	0.26332D 00	0.26512D-03	0.10075D-01	0.27688D 00	0.10926D-02	0.44836D 00	0.10603D 14	1.15097	2.92346
33	0.04323	0.26061D 00	0.27906D-03	0.10496D-01	0.27510D 00	0.11127D-02	0.45240D 00	0.10745D 14	1.22478	3.11095
34	0.04597	0.25766D 00	0.29755D-03	0.11029D-01	0.27197D 00	0.11310D-02	0.45791D 00	0.10876D 14	1.30229	3.30781
35	0.04884	0.25450D 00	0.32122D-03	0.11686D-C1	0.26762D 00	0.11478D-02	0.46473D 00	0.11000D 14	1.38367	3.51452
36	0.05186	0.25112D 00	0.35099D-03	0.12482D-01	0.26220D 00	0.11635D-02	0.47269D 00	0.11118D 14	1.46912	3.73156
37	0.05502	0.24752D 00	0.38813D-03	0.13438D-C1	0.25584D 00	0.11786D-02	0.48163D 00	0.11232D 14	1.55884	3.95945
38	0.05835	0.24372D 00	0.43445D-03	0.14585D-01	0.24866D 00	0.11933D-02	0.49141D 00	0.11342D 14	1.65305	4.19874
39	0.06184	0.23969D 00	0.49257D-03	0.15964D-01	0.24072D 00	0.12075D-02	0.50192D 00	0.11446D 14	1.75196	4.44999
40	0.06551	0.23542D 00	0.56637D-03	0.17636D-C1	0.23208D 00	0.12209D-02	0.51308D 00	0.11539D 14	1.85583	4.71380
41	0.06936	0.23089D 00	0.66176D-03	0.19689D-01	0.22272D 00	0.12326D-02	0.52481D 00	0.11610D 14	1.96489	4.99081
42	0.07340	0.22604D 00	0.78807D-03	0.22248D-01	0.21260D 00	0.12407D-02	0.53708D 00	0.11637D 14	2.07940	5.28166
43	0.07764	0.22080D 00	0.96089D-03	0.25492D-C1	0.20163D 00	0.12414D-02	0.54988D 00	0.11583D 14	2.19963	5.58706
44	0.08210	0.21508D 00	0.12089D-02	0.29671D-01	0.18961D 00	0.12286D-02	0.56319D 00	0.11388D 14	2.32588	5.90773
45	0.08678	0.20872D 00	0.15945D-02	0.35112D-01	0.17628D 00	0.11924D-02	0.57710D 00	0.10956D 14	2.45844	6.24443
46	0.09169	0.20147D 00	0.22835D-02	0.42181D-01	0.16113D 00	0.11178D-02	0.59182D 00	0.10151D 14	2.59762	6.59797
47	0.09685	0.19286D 00	0.38066D-02	0.51061D-01	0.14331D 00	0.98579D-03	0.60797D 00	0.88087D 13	2.74377	6.96918
48	0.10227	0.18178D 00	0.80512D-02	0.60954D-C1	0.12132D 00	0.77904D-03	0.62711D 00	0.68032D 13	2.89723	7.35895
49	0.10795	0.16442D 00	0.21941D-01	0.67578D-C1	0.92658D-01	0.49917D-03	0.65290D 00	0.42193D 13	3.05835	7.76822
50	0.11393	0.12531D 00	0.70344D-01	0.56865D-01	0.53727D-01	0.19683D-03	0.69356D 00	0.15975D 13	3.22754	8.19794
51	0.12020	0.0	0.23456D 00	0.0	0.0	0.0	0.76544D 00	0.0	3.40518	8.64915

Listing of the Unit 6 Output Data for the 31° Hyperboloid Binary-Gas Sample Case

FREE FLIGHT HYPERBOLOID ALT=245K FT. M=26.9 ALPHA=30, BINARY-GAS

&INPUT

ALT= 245000.0000000000 ,BRAD= 2.360833000000000 ,CAINF= 0.0 ,CAT= 1.000000000000000 ,CAW=
 0.0 ,CCFAC= 0.0 ,CONVRG= 0.9999997913837432D-02,DS= 0.200000000000000 ,DSMAX=
 3.000000000000000 ,HANGLE= 31.00000000000000 ,PRNTCI= 0.0 ,RINF= 0.867251027999999D-07,SEND=
 43.00000000000000 ,SIGM= 0.6959999880790710 ,SITEST= 0.9999999019782990D-04,SMALLT= 0.9999994290410541D-06,SSFAC=
 -1.000000000000000 ,SWFAC= -1.000000000000000 ,TB= 2460.000000000000 ,THINI= -1.000000000000000 ,TINF=
 361.48000000000000 ,UFAC= 0.500000000000000 ,UINF= 25100.000000000000 ,WVFAC= 0.250000000000000 ,XKETA=
 1.050000000000000 ,XLE= 1.399999618530273 ,XNSQ= 0.1165999770164490 ,IE= 51,IEND= 6,IGEOM= 1,
 IUN= 19,JFAC= 1,KEND= 1,KPLTTP= 0,KTWAL= 0,NAN= 1,NDATA= 1,NITMAX=
 9999,NITMIN= 3,NITMNI= 3,NS= 2,NSI= 2,NSPRF= 0,NTSH= 20,NTTWA= 5
 5

&END

LOG RATES MATCH 6 SPECIE BLOTTNER-SANDIA

113

NR	REACTION	CRO	EXP(CRO)	CR1	CR2	DRO	EXP(DRO)	DR1	DR2
1	02 02 =0 0 02	44.9274640	0.3249D 20	59400.0	-1.0	37.8379411	0.2709D 17	0.0	-0.5
2	02 0 =0 0 0	45.9491153	0.9025D 20	59400.0	-1.0	38.8595923	0.7525D 17	0.0	-0.5

ALPHSB(2, 2)

NR	ALSUB	NR	0	02
1	1.0	1	0.	2.
2	1.0	2	1.	1.

BETASB(2, 2)

NR	BETSUB	NR	0	02
1	2.0	1	2.	1.
2	2.0	2	3.	0.

GAMMPL(2, 2)

1	2.	0.
2	2.	0.

GAMMMI(2, 2)

1	0.	1.
2	0.	1.

VSREF = 0.19332065D-04

VSINF = 0.46451309D-06

```

K =1, I = 1, S = 0.0 , NITER = 1, DIFI = 4.253D 01 2.519D 00 0.0      1.000D 00
K =1, I = 1, S = 0.0 , NITER = 2, DIFI = 5.545D-01 2.008D 00 4.533D-01 1.442D 04
K =1, I = 1, S = 0.0 , NITER = 3, DIFI = 3.528D-01 2.539D-01 2.349D-01 2.542D 01
K =1, I = 1, S = 0.0 , NITER = 4, DIFI = 6.529D-02 3.417D-01 5.856D-02 9.870D 00
K =1, I = 1, S = 0.0 , NITER = 5, DIFI = 1.067D-01 3.887D-01 2.984D-01 4.251D 01
K =1, I = 1, S = 0.0 , NITER = 6, DIFI = 9.082D-02 2.376D-01 3.892D-01 7.778D 00
K =1, I = 1, S = 0.0 , NITER = 7, DIFI = 4.070D-02 3.471D-02 1.179D-01 1.504D 00
K =1, I = 1, S = 0.0 , NITER = 8, DIFI = 2.924D-02 3.617D-02 1.878D-02 9.356D-01
K =1, I = 1, S = 0.0 , NITER = 9, DIFI = 5.070D-02 3.601D-02 6.021D-02 1.115D 00
K =1, I = 1, S = 0.0 , NITER = 10, DIFI = 4.184D-02 2.709D-02 4.974D-02 9.068D-01
K =1, I = 1, S = 0.0 , NITER = 11, DIFI = 3.371D-02 2.058D-02 3.694D-02 6.673D-01
K =1, I = 1, S = 0.0 , NITER = 12, DIFI = 2.878D-02 1.745D-02 3.018D-02 5.339D-01
K =1, I = 1, S = 0.0 , NITER = 13, DIFI = 2.479D-02 1.512D-02 2.629D-02 4.379D-01
K =1, I = 1, S = 0.0 , NITER = 14, DIFI = 2.116D-02 1.279D-02 2.285D-02 3.569D-01
K =1, I = 1, S = 0.0 , NITER = 15, DIFI = 1.791D-02 1.067D-02 1.945D-02 2.908D-01
K =1, I = 1, S = 0.0 , NITER = 16, DIFI = 1.511D-02 8.9C8D-03 1.640D-02 2.368D-01
K =1, I = 1, S = 0.0 , NITER = 17, DIFI = 1.272D-02 7.455D-03 1.383D-02 1.934D-01
K =1, I = 1, S = 0.0 , NITER = 18, DIFI = 1.070D-02 6.237D-03 1.165D-02 1.583D-01
K =1, I = 1, S = 0.0 , NITER = 19, DIFI = 8.977D-03 5.207D-03 9.800D-03 1.297D-01
K =1, I = 1, S = 0.0 , NITER = 20, DIFI = 7.521D-03 4.340D-03 8.221D-03 1.065D-01
K =1, I = 1, S = 0.0 , NITER = 21, DIFI = 6.291D-03 3.615D-03 6.885D-03 8.750D-02
K =1, I = 1, S = 0.0 , NITER = 22, DIFI = 5.198D-03 3.008D-03 5.758D-03 7.204D-02
K =1, I = 1, S = 0.0 , NITER = 23, DIFI = 4.057D-03 2.198D-03 3.985D-03 5.048D-02
K =1, I = 1, S = 0.0 , NITER = 24, DIFI = 3.742D-03 2.133D-03 3.638D-03 4.678D-02
K =1, I = 1, S = 0.0 , NITER = 25, DIFI = 3.212D-03 1.893D-03 3.411D-03 4.214D-02
K =1, I = 1, S = 0.0 , NITER = 26, DIFI = 2.663D-03 1.582D-03 2.981D-03 3.611D-02
K =1, I = 1, S = 0.0 , NITER = 27, DIFI = 2.199D-03 1.304D-03 2.529D-03 3.030D-02
K =1, I = 1, S = 0.0 , NITER = 28, DIFI = 1.826D-03 1.074D-03 2.131D-03 2.526D-02
K =1, I = 1, S = 0.0 , NITER = 29, DIFI = 1.520D-03 8.824D-04 1.786D-03 2.095D-02
K =1, I = 1, S = 0.0 , NITER = 30, DIFI = 1.264D-03 7.213D-04 1.490D-03 1.729D-02
K =1, I = 1, S = 0.0 , NITER = 31, DIFI = 1.047D-03 5.871D-04 1.237D-03 1.418D-02
K =1, I = 1, S = 0.0 , NITER = 32, DIFI = 8.649D-04 4.763D-04 1.023D-03 1.159D-02
K =1, I = 1, S = 0.0 , NITER = 33, DIFI = 7.120D-04 3.852D-04 8.423D-04 9.435D-03

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```

      UINF      PINF      TINF      CAINF      TB      BRAD      PR      LE      YSH      ALT
0.251D 05 0.48676D-01 0.36148D 03 0.0      0.2460D 04 0.2361D 01 0.70D 00 0.14D 01 0.5766D-01 0.245D 06

```

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THIN SHOCK LAYER NO WALL SLIP NO SHOCK SLIP CAT WALL NO STEPS IN Y= 51 NO STEPS IN S= 6 S STEP SIZE=0.200

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      TW/TS      EPS      REYINF      REYSH      TREF      UREF      RREF      PREF      ITER
0.0637 0.0613 0.1106D 05 0.6576D 03 0.1147D 06 0.2510D 05 0.8673D-07 0.5464D 02 1

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**** FREE FLIGHT HYPERBOLIC ALT=245K FT. M=26.9 ALPHA=30, BINARY-GAS

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      S      X      R      YSH      YSHP      XSH      RSH      NO ITER      NITTOT      NTOT      I      K
0.0      0.0      0.0      0.057656 0.0      -0.057656 0.0      33      33      33      1      1

      DS      CF      HEAT      STAN      CDF      CDP      CDTOT      PWALL      TWALL      PW/PO
0.200000 0.0      0.039524 0.082447 0.0      1.763935 1.763935 0.881967 2460.000000 1.000000

```

```

      YSHP ( S      YSHP ( S+DS/2      NEW YSHP      ALPHA(S+DS/2      PHI(S+DS/2      KAPPA(S      KAPPA(S+DS/2
0.0      0.000000 0.0      1.471372 1.471372 1.000000 0.981643

```

```

      USH      VSH      TSH      RSH      PSH      VPG
0.0      -0.105803 0.333258 9.404841 0.8E5758 0.0
0.0      -2655.66 38214.38

```

N	Y/YSH	U/USH	V/VSH	T/TSH	R/RSR	P/PSH(APPR)	P/PSH	CA	CAEQ	XM	T DEG R
1	0.0	0.0	0.0	0.064374	15.467829	0.995721	1.065372	0.0	0.000002	0.0	2460.00
2	0.004777	0.041799	0.000107	0.082102	11.344995	0.995721	1.065373	0.069065	0.000278	0.000123	3137.48
3	0.009792	0.079597	0.000491	0.097529	9.021547	0.995722	1.065374	0.131751	0.004413	0.000506	3727.02
4	0.015059	0.114691	0.001185	0.111492	7.503604	0.995725	1.065375	0.190296	0.027867	0.001119	4260.59
5	0.020588	0.147769	0.002219	0.124411	6.424345	0.995729	1.065378	0.245887	0.103508	0.001945	4754.29
6	0.026394	0.179246	0.003623	0.136533	5.613617	0.995734	1.065380	0.299224	0.265575	0.002972	5217.53
7	0.032491	0.209382	0.005425	0.148012	4.980766	0.995741	1.065382	0.350738	0.502943	0.004194	5656.19
8	0.038892	0.238355	0.007656	0.158947	4.472651	0.995750	1.065383	0.400706	0.732528	0.005606	6074.06
9	0.045614	0.266281	0.010342	0.169406	4.055795	0.995761	1.065382	0.449305	0.878476	0.007205	6473.76
10	0.052671	0.293241	0.013513	0.179443	3.707887	0.995774	1.065377	0.496632	0.947201	0.008992	6857.30
11	0.060081	0.319288	0.017198	0.189105	3.413367	0.995788	1.065368	0.542715	0.976103	0.010967	7226.52
12	0.067862	0.344453	0.021426	0.198444	3.160953	0.995805	1.065353	0.587523	0.988411	0.013128	7583.43
13	0.076032	0.368754	0.026226	0.207522	2.942221	0.995823	1.065330	0.630962	0.993978	0.015479	7930.34
14	0.084610	0.392197	0.031633	0.216410	2.750747	0.995844	1.065298	0.672886	0.996676	0.018023	8269.96
15	0.093617	0.414780	0.037680	0.225187	2.581544	0.995867	1.065255	0.713101	0.998072	0.020765	8605.38
16	0.103075	0.436495	0.044406	0.233943	2.430701	0.995892	1.065198	0.751373	0.998836	0.023710	8939.99
17	0.113006	0.457335	0.051850	0.242770	2.295148	0.995920	1.065125	0.787438	0.999274	0.026867	9277.32
18	0.123433	0.477291	0.060056	0.251758	2.172453	0.995950	1.065033	0.821021	0.999536	0.030245	9620.79
19	0.134381	0.496361	0.069063	0.260984	2.060909	0.995982	1.064919	0.851854	0.999697	0.033853	9973.34
20	0.145877	0.514549	0.078910	0.270504	1.959036	0.996017	1.064780	0.879696	0.999799	0.037696	10337.14
21	0.157947	0.531868	0.089625	0.280344	1.865907	0.996054	1.064613	0.904358	0.999865	0.041780	10713.16
22	0.170621	0.548342	0.101224	0.290487	1.780882	0.996093	1.064413	0.925726	0.999907	0.046110	11100.77
23	0.183929	0.564008	0.113703	0.300867	1.703573	0.996135	1.064178	0.943784	0.999935	0.050685	11497.43
24	0.197902	0.578915	0.127035	0.311364	1.633765	0.996180	1.063905	0.958624	0.999954	0.055499	11898.58
25	0.212574	0.593126	0.141168	0.321810	1.571338	0.996227	1.063593	0.970448	0.999966	0.060541	12297.76
26	0.227980	0.606715	0.156023	0.331997	1.516193	0.996277	1.063239	0.979559	0.999975	0.065798	12687.07
27	0.244155	0.619764	0.171509	0.341702	1.468186	0.996330	1.062843	0.986330	0.999980	0.071254	13057.91
28	0.261140	0.632369	0.187523	0.350704	1.427087	0.996387	1.062406	0.991174	0.999984	0.076893	13401.93
29	0.278974	0.644629	0.203972	0.358817	1.392553	0.996446	1.061927	0.994506	0.999987	0.082702	13711.98
30	0.297699	0.656651	0.220781	0.365907	1.364131	0.996510	1.061407	0.996705	0.999989	0.088677	13982.92
31	0.317361	0.668546	0.237904	0.371904	1.341267	0.996578	1.060843	0.998095	0.999990	0.094822	14212.08
32	0.338006	0.680426	0.255336	0.376805	1.323338	0.996651	1.060235	0.998937	0.999991	0.101150	14399.35
33	0.359683	0.692403	0.273109	0.380667	1.309674	0.996729	1.059578	0.999421	0.999992	0.107683	14546.94
34	0.382443	0.704588	0.291295	0.383595	1.299592	0.996813	1.058865	0.999684	0.999992	0.114451	14658.86
35	0.406342	0.717086	0.310002	0.385728	1.292423	0.996903	1.058088	0.999814	0.999993	0.121495	14740.37
36	0.431436	0.729993	0.329367	0.387218	1.287531	0.997001	1.057235	0.999862	0.999993	0.128859	14797.31
37	0.457785	0.743397	0.349546	0.388218	1.284344	0.997108	1.056293	0.999857	0.999993	0.136596	14835.53
38	0.485451	0.757378	0.370710	0.388872	1.282359	0.997223	1.055244	0.999806	0.999993	0.144760	14860.50
39	0.514500	0.772004	0.393035	0.389305	1.281154	0.997348	1.054069	0.999701	0.999993	0.153407	14877.07
40	0.545002	0.787332	0.416704	0.389630	1.280379	0.997485	1.052745	0.999511	0.999993	0.162597	14889.47
41	0.577029	0.803414	0.441908	0.389948	1.279735	0.997634	1.051245	0.999180	0.999993	0.172391	14901.62
42	0.610657	0.820294	0.468861	0.390369	1.278932	0.997796	1.049539	0.998596	0.999993	0.182860	14917.71
43	0.645966	0.838011	0.497829	0.391043	1.277616	0.997974	1.047584	0.997552	0.999993	0.194089	14943.48
44	0.683041	0.856594	0.529190	0.392217	1.275240	0.998167	1.045327	0.995659	0.999994	0.206195	14988.35
45	0.721970	0.876057	0.563558	0.394347	1.270844	0.998379	1.042679	0.992158	0.999994	0.219363	15069.71
46	0.762845	0.896388	0.602050	0.398333	1.262606	0.998610	1.039492	0.985525	0.999994	0.233913	15222.03
47	0.805764	0.917514	0.646914	0.406094	1.246941	0.998861	1.035465	0.972505	0.999995	0.250484	15518.63
48	0.850829	0.939237	0.703167	0.422154	1.216488	0.999132	1.029906	0.945441	0.999996	0.270484	16132.36
49	0.898148	0.961086	0.783315	0.459144	1.155816	0.999418	1.021075	0.883076	0.999998	0.297423	17545.92
50	0.947832	0.981973	0.918610	0.563235	1.038886	0.999707	1.009357	0.708268	0.999999	0.341581	21523.68
51	1.000000	1.000000	1.002390	1.000000	1.000000	1.000000	1.000000	0.0	1.000000	0.359847	38214.38

K =1, I = 2, S = 0.200, NITER = 1, DIFI = 3.924D-02 7.939D-02 1.934D-02 8.090D-01
 K =1, I = 2, S = 0.200, NITER = 2, DIFI = 4.566D-02 8.799D-03 5.121D-03 1.371D-01
 K =1, I = 2, S = 0.200, NITER = 3, DIFI = 3.382D-03 5.031D-03 5.092D-03 9.156D-02
 K =1, I = 2, S = 0.200, NITER = 4, DIFI = 7.382D-04 1.716D-03 2.521D-04 3.451D-03

**** FREE FLIGHT HYPERBOLOID ALT=245K FT. M=26.9 ALPHA=30, BINARY-GAS

S	X	R	YSH	YSHP	XSH	RSH	NO ITER	NITTOT	NTOT	I	K
0.200000	0.019709	0.198780	0.059531	0.018751	-0.038690	0.210333	4	37	37	2	1
DS	CF	HEAT	STAN	CDF	CDP	CDTOT	PWALL	TWALL	PW/PO		
0.200000	0.013979	0.037700	0.078641	0.002730	1.655929	1.658658	0.838862	2460.000000	0.951126		
YSHP (S	YSHP (S+DS/2	NEW YSHP	ALPHA(S+DS/2	PHI(S+DS/2	KAPPA(S	KAPPA(S+DS/2					
0.000000	0.000000	0.018751	1.286004	1.286004	0.930449	0.856159					
USH	VSH	TSH	RSH	PSH	VPG						
0.190109	-0.103686	0.321006	9.426875	0.855116	0.0						
4771.75	-2602.52	36809.47									
		20449.72									

116

K =1, I = 3, S = 0.400, NITER = 1, DIFI = 7.148D-02 1.372D-01 6.955D-02 6.379D-00
 K =1, I = 3, S = 0.400, NITER = 2, DIFI = 8.167D-02 2.808D-02 2.000D-02 3.596D-01
 K =1, I = 3, S = 0.400, NITER = 3, DIFI = 1.005D-02 1.116D-02 1.213D-02 2.055D-01
 K =1, I = 3, S = 0.400, NITER = 4, DIFI = 2.866D-03 3.254D-03 1.402D-03 1.299D-02
 K =1, I = 3, S = 0.400, NITER = 5, DIFI = 3.501D-04 1.093D-03 1.654D-03 2.665D-02
 K =1, I = 3, S = 0.400, NITER = 6, DIFI = 4.410D-04 2.363D-04 1.825D-04 7.441D-03

**** FREE FLIGHT HYPERBOLOID ALT=245K FT. M=26.9 ALPHA=30, BINARY-GAS

S	X	R	YSH	YSHP	XSH	RSH	NO ITER	NITTOT	NTOT	I	K
0.400000	0.075579	0.390592	0.064482	0.030753	0.015372	0.413680	6	43	43	3	1
DS	CF	HEAT	STAN	CDF	CDP	CDTOT	PWALL	TWALL	PW/PO		
0.200000	0.023314	0.033295	0.069452	0.005688	1.562459	1.568147	0.736973	2460.000000	0.835601		
YSHP (S	YSHP (S+DS/2	NEW YSHP	ALPHA(S+DS/2	PHI(S+DS/2	KAPPA(S	KAPPA(S+DS/2					
0.000000	0.000000	0.030753	1.132012	1.132012	0.770250	0.682420					
USH	VSH	TSH	RSH	PSH	VPG						
0.352899	-0.098578	0.291473	9.459808	0.779173	0.0						
8857.76	-2474.30	33422.95									
		18568.31									

K =1, I = 4, S = 0.600, NITER = 1, DIFI = 6.459D-02 1.516D-01 1.321D-01 1.030D 01
 K =1, I = 4, S = 0.600, NITER = 2, DIFI = 6.893D-02 2.434D-02 3.315D-02 3.028D-01
 K =1, I = 4, S = 0.600, NITER = 3, DIFI = 1.645D-02 1.355D-02 1.847D-02 2.240D-01
 K =1, I = 4, S = 0.600, NITER = 4, DIFI = 4.162D-03 3.551D-03 2.558D-03 1.829D-02
 K =1, I = 4, S = 0.600, NITER = 5, DIFI = 1.614D-03 9.928D-04 2.681D-03 2.767D-02
 K =1, I = 4, S = 0.600, NITER = 6, DIFI = 4.551D-04 2.645D-04 1.877D-04 5.134D-03

**** FREE FLIGHT HYPERBOLOID ALT=245K FT. M=26.9 ALPHA=30, BINARY-GAS

S	X	R	YSH	YSHP	XSH	RSH	NO ITER	NITTOT	NTOT	I	K
0.600000	0.160212	0.571609	0.071395	0.038378	0.097653	0.606013	6	49	49	4	1
DS	CF	HEAT	STAN	CDF	CDP	CDTOT	PWALL	TWALL		PW/PO	
0.200000	0.027301	0.028282	0.058996	0.009255	1.441426	1.450681	0.624348	2460.000000		0.707904	
YSHP (S	YSHP (S+DS/2	NEW YSHP	ALPHA(S+DS/2	PHI(S+DS/2	KAPPA(S	KAPPA(S+DS/2					
-0.000000	0.000000	0.038378	1.011943	1.011943	0.599116	0.523715					
USH	VSH	TSH	RSH	PSH	VPG						
0.477527	-0.092728	0.257784	9.452562	0.688719	0.0						
11985.92	-2327.47	29559.90									
		16422.17									

K =1, I = 5, S = 0.800, NITER = 1, DIFI = 5.100D-02 1.379D-01 1.909D-01 5.540D 00
 K =1, I = 5, S = 0.800, NITER = 2, DIFI = 3.851D-02 1.789D-02 4.861D-02 2.103D-01
 K =1, I = 5, S = 0.800, NITER = 3, DIFI = 2.323D-02 1.496D-02 2.304D-02 1.618D-01
 K =1, I = 5, S = 0.800, NITER = 4, DIFI = 2.381D-03 2.933D-03 4.452D-03 1.678D-02
 K =1, I = 5, S = 0.800, NITER = 5, DIFI = 2.930D-03 1.340D-03 3.373D-03 1.762D-02
 K =1, I = 5, S = 0.800, NITER = 6, DIFI = 1.679D-04 2.755D-04 1.208D-04 1.358D-03

**** FREE FLIGHT HYPERBOLOID ALT=245K FT. M=26.9 ALPHA=30, BINARY-GAS

S	X	R	YSH	YSHP	XSH	RSH	NO ITER	NITTOT	NTOT	I	K
0.800000	0.265984	0.741194	0.079502	0.042695	0.200721	0.786596	6	55	55	5	1
DS	CF	HEAT	STAN	CDF	CDP	CDTOT	PWALL	TWALL		PW/PO	
0.200000	0.027935	0.023873	0.049799	0.012547	1.318926	1.331473	0.528085	2460.000000		0.598757	
YSHP (S	YSHP (S+DS/2	NEW YSHP	ALPHA(S+DS/2	PHI(S+DS/2	KAPPA(S	KAPPA(S+DS/2					
0.000000	0.000000	0.042695	0.920184	0.920184	0.457400	0.400051					
USH	VSH	TSH	RSH	PSH	VPG						
0.567944	-0.087477	0.227832	9.393196	0.604957	0.0						
14255.39	-2195.68	26125.29									
		14514.06									

K =1, I = 6, S = 1.000, NITER = 1, DIFI = 4.033D-02 1.195D-01 2.316D-01 2.382D 00
 K =1, I = 6, S = 1.000, NITER = 2, DIFI = 1.000D-02 1.730D-02 6.420D-02 1.235D-01
 K =1, I = 6, S = 1.000, NITER = 3, DIFI = 2.767D-02 1.560D-02 2.524D-02 9.768D-02
 K =1, I = 6, S = 1.000, NITER = 4, DIFI = 2.814D-03 3.406D-03 6.291D-03 1.173D-02
 K =1, I = 6, S = 1.000, NITER = 5, DIFI = 3.578D-03 1.307D-03 3.487D-03 8.456D-03

**** FREE FLIGHT HYPERBOLOID ALT=245K FT. M=26.9 ALPHA=30, BINARY-GAS

S	X	R	YSH	YSHP	XSH	RSH	NO ITER	NITTOT	NTOT	I	K
1.000000	0.386918	0.900366	0.088349	0.045774	0.318672	0.956473	5	60	60	6	1
DS	CF	HEAT	STAN	CDF	CDP	CDTOT	PWALL	TWALL		PW/PO	
0.200000	0.027041	0.020347	0.042443	0.015234	1.208064	1.223298	0.453728	2460.000000		0.514450	
YSHP (S	YSHP (S+DS/2	NEW YSHP	ALPHA(S+DS/2	PHI(S+DS/2	KAPPA(S	KAPPA(S+DS/2					
0.000000	0.000000	0.045774	0.849778	0.849778	0.350905	0.308952					
USH	VSH	TSH	RSH	PSH	VPG						
0.632912	-0.083156	0.203588	9.299610	0.535214	0.0						
15886.08	-2087.23	23345.19									
		12969.55									

N	Y/YSH	U/USH	V/VSH	T/TSH	R/RSR	P/PSH(APPR)	P/PSH	CA	CAEQ	XM	T DEG R
1	0.0	0.0	0.0	0.105667	8.050302	0.847752	0.917449	0.0	0.000003	0.0	2466.81
2	0.004777	0.036003	0.000056	0.131821	6.120752	0.847756	0.917453	0.052327	0.000273	0.251505	3077.39
3	0.009792	0.069244	0.000257	0.153923	5.004202	0.847773	0.917469	0.100634	0.003502	0.440980	3593.37
4	0.015059	0.100716	0.000628	0.173325	4.261213	0.847811	0.917506	0.146427	0.019302	0.595177	4046.30
5	0.020588	0.130954	0.001191	0.190735	3.724962	0.847875	0.917568	0.190529	0.065651	0.726231	4452.74
6	0.026394	0.160276	0.001972	0.206585	3.316734	0.847968	0.917659	0.233433	0.162116	0.840647	4822.76
7	0.032491	0.188885	0.002997	0.221156	2.994102	0.848094	0.917782	0.275453	0.314721	0.942390	5162.93
8	0.038892	0.216911	0.004293	0.234642	2.731987	0.848256	0.917939	0.316790	0.501759	1.034031	5477.76
9	0.045614	0.244438	0.005889	0.247183	2.514512	0.848458	0.918135	0.357571	0.679370	1.117358	5770.52
10	0.052671	0.271514	0.007815	0.258883	2.331075	0.848703	0.918373	0.397872	0.811933	1.193819	6043.68
11	0.060081	0.298166	0.010103	0.269829	2.174284	0.848994	0.918656	0.437723	0.894061	1.264352	6299.20
12	0.067862	0.324395	0.012787	0.280092	2.038795	0.849335	0.918986	0.477120	0.939952	1.329654	6538.79
13	0.076032	0.350192	0.015903	0.289739	1.920632	0.849731	0.919368	0.516020	0.964842	1.390326	6764.02
14	0.084610	0.375529	0.019486	0.298837	1.816767	0.850184	0.919805	0.554350	0.978537	1.446762	6976.41
15	0.093617	0.400371	0.023577	0.307450	1.724840	0.850700	0.920301	0.592003	0.986337	1.499168	7177.49
16	0.103075	0.424672	0.028217	0.315646	1.642990	0.851283	0.920856	0.628842	0.990962	1.547780	7368.81
17	0.113006	0.448379	0.033447	0.323489	1.569734	0.851936	0.921480	0.664704	0.993818	1.592796	7551.91
18	0.123433	0.471438	0.039311	0.331044	1.503884	0.852664	0.922171	0.699398	0.995649	1.634398	7728.27
19	0.134381	0.493794	0.045855	0.338368	1.444494	0.853472	0.922932	0.732719	0.996862	1.672774	7899.25
20	0.145877	0.515395	0.053122	0.345509	1.390813	0.854363	0.923766	0.764444	0.997689	1.708136	8065.98
21	0.157947	0.536196	0.061155	0.352504	1.342261	0.855343	0.924676	0.794348	0.998267	1.740829	8229.28
22	0.170621	0.556164	0.069993	0.359369	1.298397	0.856415	0.925663	0.822210	0.998679	1.771088	8389.54
23	0.183929	0.575280	0.079666	0.366099	1.258906	0.857584	0.926731	0.847821	0.998977	1.799243	8546.65
24	0.197902	0.593541	0.090198	0.372663	1.223578	0.858855	0.927880	0.870998	0.999196	1.825722	8699.88
25	0.212574	0.610964	0.101599	0.379002	1.192289	0.860235	0.929114	0.891593	0.999357	1.851017	8847.87
26	0.227980	0.627988	0.113867	0.385032	1.164984	0.861729	0.930435	0.909502	0.999746	1.875684	8988.64
27	0.244155	0.643468	0.126981	0.390645	1.141656	0.863345	0.931848	0.924669	0.999564	1.900319	9119.67
28	0.261140	0.658682	0.140907	0.395717	1.122326	0.865092	0.933360	0.937095	0.999629	1.925547	9238.08
29	0.278974	0.673323	0.155601	0.400122	1.107015	0.866983	0.934977	0.946827	0.999676	1.951994	9340.92
30	0.297699	0.687500	0.171007	0.403745	1.095727	0.869028	0.936710	0.953957	0.999710	1.980262	9425.49
31	0.317361	0.701328	0.187078	0.406498	1.088422	0.871246	0.938573	0.958607	0.999732	2.010902	9489.77
32	0.338006	0.714932	0.203772	0.408338	1.085000	0.873655	0.940579	0.960915	0.999746	2.044390	9532.74
33	0.359683	0.728433	0.221077	0.409279	1.085280	0.876277	0.942747	0.961017	0.999752	2.081114	9554.70
34	0.382443	0.741951	0.239008	0.409396	1.088991	0.879137	0.945097	0.959030	0.999752	2.121315	9557.42
35	0.406342	0.755593	0.257626	0.408826	1.095774	0.882266	0.947649	0.955042	0.999747	2.165132	9544.12
36	0.431436	0.769451	0.277032	0.407758	1.105193	0.885697	0.950427	0.949096	0.999738	2.212602	9519.20
37	0.457785	0.783599	0.297365	0.406418	1.116758	0.889465	0.953451	0.941187	0.999725	2.263642	9487.89
38	0.485451	0.798089	0.318799	0.405045	1.129957	0.893612	0.956744	0.931259	0.999712	2.318084	9455.86
39	0.514500	0.812949	0.341530	0.403887	1.144286	0.898181	0.960326	0.919202	0.999699	2.375712	9428.81
40	0.545002	0.828188	0.365772	0.403181	1.159272	0.903219	0.964216	0.904857	0.999689	2.436276	9412.34
41	0.577029	0.843795	0.391752	0.403169	1.174463	0.908777	0.968428	0.888010	0.999685	2.499499	9412.05
42	0.610657	0.859739	0.419732	0.404107	1.189393	0.914908	0.972972	0.868396	0.999688	2.565047	9433.95
43	0.645966	0.875976	0.450029	0.406309	1.203510	0.921665	0.977846	0.845676	0.999703	2.632480	9485.35
44	0.683041	0.892441	0.483077	0.410201	1.216056	0.929104	0.983029	0.819410	0.999728	2.701197	9576.22
45	0.721970	0.909052	0.519528	0.416436	1.225876	0.937276	0.988464	0.788961	0.999767	2.770290	9721.78
46	0.762845	0.925695	0.560465	0.426111	1.231037	0.946218	0.994018	0.753294	0.999815	2.838079	9947.65
47	0.805764	0.942218	0.607873	0.441289	1.228214	0.955946	0.999404	0.710457	0.999870	2.901853	10301.97
48	0.850829	0.958399	0.665812	0.466405	1.211172	0.966421	1.003963	0.656121	0.999925	2.956807	10888.32
49	0.898148	0.973889	0.743720	0.512991	1.167655	0.977488	1.006091	0.578614	0.999969	2.994015	11975.87
50	0.947832	0.988084	0.864811	0.620638	1.075938	0.988768	1.004440	0.436357	0.999993	3.000035	14488.92
51	1.000000	1.000000	0.989477	1.000000	1.000000	1.000000	1.000000	0.0	1.000000	3.050047	23345.19

Listing of the Unit 6 Output Data for the 31° Hyperboloid 7-Species Sample Case

FREE FLIGHT HYPERBOLOID ALT=245K FT. M=26.9 ALPHA=30, 7-SPECIES

&INPUT

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ALT= 245000.0000000000 ,BRAD= 2.360833000000000 ,CAINF= 0.0 ,CAT= 1.000000000000000 ,CAW=
0.0 ,CCFAC= 0.0 ,CONVRG= 0.9999997913837432D-02,DS= 0.200000000000000 ,DSMAX=
3.000000000000000 ,HANGLE= 31.00000000000000 ,PRNTCI= 0.0 ,RINF= 0.867251027999999D-07,SEND=
43.000000000000000 ,SIGM= 0.6999999880790710 ,SITEST= 0.9999999019782990D-04,SMALLT= 0.9999994290410541D-06,SSFAC=
-1.000000000000000 ,SWFAC= -1.000000000000000 ,TB= 2460.000000000000 ,THINI= -1.000000000000000 ,TINF=
361.4800000000000 ,UFAC= 0.500000000000000 ,UINF= 25100.00000000000 ,WVFAC= 0.250000000000000 ,XKETA=
1.050000000000000 ,XLE= 1.399999618530273 ,XNS0= 0.1165999770164490 ,IE= 51, IEND= 6, IGEOM= 1,
IUN= 19, JFAC= 1, KEND= 1, KPLTTP= 0, KTVAL= 0, NAN= 1, NDATA= 1, NITMAX= 1,
9999, NITMIN= 3, NITMNI= 3, NS= 6, NSI= 6, NSPRF= 0, NTSH= 20, NTTWA= 5

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&END

LOG RATES MATCH 6 SPECIE BLOTTNER-SANDIA

NR	REACTION			CRO	EXP(CRO)	CR1	CR2	DRO	EXP(DRO)	DR1	DR2
1	O2	M1	=O C M1	42.7302394	0.3610D 19	59400.0	-1.0	35.6407165	0.3010D 16	0.0	-0.5
2	N2	M2	=N N M2	39.7962718	0.1920D 18	113100.0	-0.5	36.9275392	0.1090D 17	0.0	-0.5
3	N2	N	=N N N	52.0799804	0.4150D 23	113100.0	-1.5	49.1958541	0.2320D 22	0.0	-1.5
4	N2	M3	=N O M3	47.4304680	0.3970D 21	75600.0	-1.5	46.0616522	0.1010D 21	0.0	-1.5
5	NO	O	=O2 N	21.8801470	0.3180D 10	19700.0	1.0	27.5933192	0.9630D 12	3600.0	0.5
6	N2	O	=NO N	31.8431487	0.6750D 14	37500.0	0.0	30.3390713	0.1500D 14	0.0	0.0
7	N	O	=NO+ EL	22.9238182	0.9030D 10	32400.0	0.5	44.3369034	0.1800D 20	0.0	-1.0

ALPHSR (7,10)

NR	ALSUB	NR	O	O2	NO	N	NO+	N2	M1	M2	M3	EL
1	1.0	1	0.	1.	0.	0.	0.	0.	1.	0.	0.	0.
2	1.0	2	0.	0.	0.	0.	0.	1.	0.	1.	0.	0.
3	1.0	3	0.	0.	0.	1.	0.	1.	0.	0.	0.	0.
4	1.0	4	0.	0.	1.	0.	0.	0.	0.	0.	1.	0.
5	1.0	5	1.	0.	1.	0.	0.	0.	0.	0.	0.	0.
6	1.0	6	1.	0.	0.	0.	0.	1.	0.	0.	0.	0.
7	1.0	7	1.	0.	0.	1.	0.	0.	0.	0.	0.	0.

BETASB(7,10)												
NR	BETSUB	NR	O	O2	NO	N	NC+	N2	M1	M2	M3	EL
1	2.0	1	2.	0.	0.	0.	0.	0.	1.	0.	0.	0.
2	2.0	2	0.	0.	0.	2.	0.	0.	0.	1.	0.	0.
3	2.0	3	0.	0.	0.	3.	0.	0.	0.	0.	0.	0.
4	2.0	4	1.	0.	0.	1.	0.	0.	0.	0.	1.	0.
5	1.0	5	0.	1.	0.	1.	0.	0.	0.	0.	0.	0.
6	1.0	6	0.	0.	1.	1.	0.	0.	0.	0.	0.	0.
7	1.0	7	0.	0.	0.	0.	1.	0.	0.	0.	0.	1.

ZSUB(4, 6)

	O	O2	NO	N	NO+	N2
M1	25.0	9.0	1.0	1.0	0.0	2.0
M2	1.0	1.0	1.0	0.0	0.0	2.5
M3	20.0	1.0	20.0	20.0	0.0	1.0
EL	0.0	0.0	0.0	0.0	1.0	0.0

GAMMPL(7, 6)

1	2.	0.	0.	0.	0.	0.
2	0.	0.	0.	2.	0.	0.
3	0.	0.	0.	2.	0.	0.
4	1.	0.	0.	1.	0.	0.
5	0.	1.	0.	1.	0.	0.
6	0.	0.	1.	1.	0.	0.
7	0.	0.	0.	0.	1.	0.

GAMMMI(7, 6)

1	0.	1.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	1.
3	0.	0.	0.	0.	0.	1.
4	0.	0.	1.	0.	0.	0.
5	1.	0.	1.	0.	0.	0.
6	1.	0.	0.	0.	0.	1.
7	1.	0.	0.	1.	0.	0.

VSREF = 0.233539990-04

VSINF = 0.358679110-06

K =1, I = 1, S = 0.0	, NITER = 1, DIFI = 3.883D 01 4.979D 00 0.0	1.000D 00 0.0	0.0	0.0	7.590D-01
K =1, I = 1, S = 0.0	, NITER = 2, DIFI = 6.558D-01 2.953D-01 8.918D-01	7.080D 02 8.909D 16	4.265D 17	9.433D 35	1.597D 00
K =1, I = 1, S = 0.0	, NITER = 3, DIFI = 4.204D-01 9.776D-01 3.333D 01	3.417D 03 1.864D 00	9.662D-01	9.946D-01	5.284D 01
K =1, I = 1, S = 0.0	, NITER = 4, DIFI = 2.643D 00 5.280C 00 9.097D-01	1.945D 02 2.218D 03	3.545D 00	1.496D 01	1.677D 01
K =1, I = 1, S = 0.0	, NITER = 5, DIFI = 1.445D-01 2.909D 01 8.622D-01	1.698D 02 3.141D 01	3.014D 02	5.858D 14	2.379D 01
K =1, I = 1, S = 0.0	, NITER = 6, DIFI = 2.724D-01 7.607D 00 3.954D 01	3.600D 36 5.444D-01	1.850D 08	2.243D 00	1.248D 00
K =1, I = 1, S = 0.0	, NITER = 7, DIFI = 1.294D 00 6.822D-01 9.907D-01	9.258D 00 9.310D 01	1.000D 00	7.918D 11	4.182D 00
K =1, I = 1, S = 0.0	, NITER = 8, DIFI = 4.327D-01 6.252D-01 1.000D 00	1.820D 36 9.857D-01	1.263D 06	1.000D 00	9.925D 00
K =1, I = 1, S = 0.0	, NITER = 9, DIFI = 5.729D-01 1.440D 00 1.399D 39	2.439D 38 1.000D 00	1.000D 00	1.439D 09	3.926D-01
K =1, I = 1, S = 0.0	, NITER = 10, DIFI = 6.240D-01 1.308D 00 7.172D 00	1.615D 01 1.135D 05	2.256D 05	1.721D 00	2.298D-01
K =1, I = 1, S = 0.0	, NITER = 11, DIFI = 4.947D-02 1.870C-01 7.712D 39	2.391D 39 9.818D 00	9.999D-01	1.239D 08	7.244D-01
K =1, I = 1, S = 0.0	, NITER = 12, DIFI = 4.306D-01 4.544D-01 1.672D 02	9.507D 39 1.389D 39	6.073D 03	1.000D 00	2.727D 00
K =1, I = 1, S = 0.0	, NITER = 13, DIFI = 3.172D-01 1.527D 00 1.000D 40	1.980D 00 5.110D 01	1.000D 00	4.075D 08	1.816D 00
K =1, I = 1, S = 0.0	, NITER = 14, DIFI = 7.654D-01 2.458D 00 1.000D 00	1.032D 37 3.646D 38	5.370D 05	1.000D 00	9.323D 01
K =1, I = 1, S = 0.0	, NITER = 15, DIFI = 5.397D-01 6.285D 00 1.460D 39	2.399D 36 9.992D-01	9.753D-01	1.049D 07	3.312D-01
K =1, I = 1, S = 0.0	, NITER = 16, DIFI = 1.526D 00 8.234D-01 1.020D 03	4.255D 39 9.381D 02	6.824D 03	1.000D 00	2.302D 00
K =1, I = 1, S = 0.0	, NITER = 17, DIFI = 6.093D-01 4.193D 00 1.000D 00	7.018D 01 2.488D 02	1.000D 00	4.436D 06	1.157D 01
K =1, I = 1, S = 0.0	, NITER = 18, DIFI = 8.310D-01 7.888D-01 1.000D 00	1.003D 00 2.180D 00	8.862D 06	2.688D 00	6.866D 00
K =1, I = 1, S = 0.0	, NITER = 19, DIFI = 4.922D-01 4.760D 00 1.702D 39	4.158D 00 1.247D 39	1.000D 00	9.734D 03	4.831D 00
K =1, I = 1, S = 0.0	, NITER = 20, DIFI = 8.839D 00 4.908D 00 2.720D 05	4.470D 39 1.000D 00	1.437D 05	7.835D 00	6.134D-01
K =1, I = 1, S = 0.0	, NITER = 21, DIFI = 8.217D-01 2.689C-01 1.107D 00	1.660D 01 5.686D 39	9.989D-01	4.108D 05	2.474D 00
K =1, I = 1, S = 0.0	, NITER = 22, DIFI = 2.455D-01 5.078D-01 4.793D 03	1.000D 00 2.410D 00	7.208D 02	7.850D 00	1.023D 02
K =1, I = 1, S = 0.0	, NITER = 23, DIFI = 7.639D-01 4.932D-01 9.953D-01	1.000D 00 8.188D 00	1.619D 00	5.227D 04	7.979D 00
K =1, I = 1, S = 0.0	, NITER = 24, DIFI = 5.527D-01 3.594C-01 2.120D 02	1.186D 39 9.913D-01	2.453D 04	1.000D 00	3.069D 01
K =1, I = 1, S = 0.0	, NITER = 25, DIFI = 1.672D 00 4.639D-01 1.000D 00	1.000D 00 1.140D 02	1.000D 00	8.851D 03	9.107D 00
K =1, I = 1, S = 0.0	, NITER = 26, DIFI = 5.484D-01 2.513D-01 3.747D 04	6.383D 38 9.747D-01	3.692D 04	9.999D-01	1.345D 03
K =1, I = 1, S = 0.0	, NITER = 27, DIFI = 1.534D 00 2.780D-01 1.000D 00	1.000D 00 3.853D 01	1.000D 00	1.729D 04	1.609D 01
K =1, I = 1, S = 0.0	, NITER = 28, DIFI = 6.073D-01 3.732C-01 1.000D 00	9.366D 38 1.000D 00	1.298D 05	1.000D 00	1.763D 04
K =1, I = 1, S = 0.0	, NITER = 29, DIFI = 1.144D 00 1.016D 01 7.095D 38	4.025D 38 2.978D 38	7.374D 00	6.987D 00	1.463D-01
K =1, I = 1, S = 0.0	, NITER = 30, DIFI = 1.000D 00 1.000D 00 3.176D 00	1.000D 40 3.162D 01	1.093D 00	7.280D 01	1.006D 00
K =1, I = 1, S = 0.0	, NITER = 31, DIFI = 2.433D 02 1.585D 05 2.563D 37	2.238D 00 9.973D-01	2.497D 35	2.665D 34	2.906D 02
K =1, I = 1, S = 0.0	, NITER = 32, DIFI = 6.234D 03 2.379D 05 1.520D 01	1.000D 40 8.388D 02	8.538D 36	1.000D 00	1.026D 00
K =1, I = 1, S = 0.0	, NITER = 33, DIFI = 1.564D 05 3.123D 00 2.547D 05	3.323D 01 5.377D 01	1.000D 00	5.313D 12	9.966D 04
K =1, I = 1, S = 0.0	, NITER = 34, DIFI = 6.607D-01 7.042D-01 1.059D 01	6.186D-01 1.706D 00	3.362D 08	2.045D 00	1.268D-01
K =1, I = 1, S = 0.0	, NITER = 35, DIFI = 2.903D-01 1.340C-01 1.216D 00	8.006D-01 4.011D 00	4.969D 02	8.127D 02	3.519D-01
K =1, I = 1, S = 0.0	, NITER = 36, DIFI = 1.863D-01 1.720D-01 3.805D-01	4.359D-01 3.370D-01	3.736D 00	7.835D 00	2.209D-01
K =1, I = 1, S = 0.0	, NITER = 37, DIFI = 1.367D-01 6.267C-02 8.082D-01	6.229D-01 5.136D-01	1.415D 00	7.613D-01	4.257D-01
K =1, I = 1, S = 0.0	, NITER = 38, DIFI = 1.272D-01 7.205D-02 1.753D-01	2.493D-01 4.730D-01	1.102D 00	5.155D 00	2.451D-01
K =1, I = 1, S = 0.0	, NITER = 39, DIFI = 7.789D-02 2.380D-02 1.595D-01	6.033D-01 2.549D-01	6.172D-01	7.203D-01	1.791D-01
K =1, I = 1, S = 0.0	, NITER = 40, DIFI = 6.448D-02 5.423D-02 1.722D-01	2.680D-01 2.939D-01	4.272D-01	2.343D 00	1.658D-01

K =1, I = 1, S = 0.0 , NITER = 41, DIFI = 4.193D-02 5.174D-02 8.346D-02 4.822D-01 1.322D-01 4.418D-01 5.163D-01 2.820D-02
 K =1, I = 1, S = 0.0 , NITER = 42, DIFI = 3.507D-02 3.168D-02 8.943D-02 2.996D-01 2.228D-01 3.268D-01 1.224D 00 4.410D-02
 K =1, I = 1, S = 0.0 , NITER = 43, DIFI = 2.398D-02 2.004D-02 8.370D-02 3.471D-01 1.484D-01 2.704D-01 4.023D-01 4.179D-02
 K =1, I = 1, S = 0.0 , NITER = 44, DIFI = 1.725D-02 8.480D-03 6.963D-02 2.838D-01 1.601D-01 1.836D-01 6.361D-01 3.187D-02
 K =1, I = 1, S = 0.0 , NITER = 45, DIFI = 1.250D-02 8.762D-03 6.094D-02 2.617D-01 1.296D-01 1.466D-01 3.062D-01 2.027D-02
 K =1, I = 1, S = 0.0 , NITER = 46, DIFI = 8.784D-03 4.274D-03 4.524D-02 2.306D-01 1.188D-01 1.144D-01 3.729D-01 1.483D-02
 K =1, I = 1, S = 0.0 , NITER = 47, DIFI = 6.3C8D-03 3.303D-03 3.840D-02 1.934D-01 9.775D-02 8.962D-02 2.184D-01 1.067D-02
 K =1, I = 1, S = 0.0 , NITER = 48, DIFI = 4.566D-03 2.945D-03 2.750D-02 1.661D-01 8.533D-02 6.732D-02 2.179D-01 7.802D-03
 K =1, I = 1, S = 0.0 , NITER = 49, DIFI = 3.261D-03 2.579D-03 2.315D-02 1.334D-01 6.818D-02 5.501D-02 1.492D-01 5.944D-03
 K =1, I = 1, S = 0.0 , NITER = 50, DIFI = 2.311D-03 2.387D-03 1.576D-02 1.114D-01 5.749D-02 4.170D-02 1.305D-01 4.143D-03
 K =1, I = 1, S = 0.0 , NITER = 51, DIFI = 1.670D-03 1.880D-03 1.324D-02 8.669D-02 4.496D-02 3.341D-02 9.795D-02 3.205D-03
 K =1, I = 1, S = 0.0 , NITER = 52, DIFI = 1.195D-03 1.742D-03 8.859D-03 7.090D-02 3.714D-02 2.563D-02 7.802D-02 2.258D-03
 K =1, I = 1, S = 0.0 , NITER = 53, DIFI = 9.920D-04 1.303D-03 7.563D-03 5.421D-02 2.847D-02 2.060D-02 6.197D-02 1.782D-03
 K =1, I = 1, S = 0.0 , NITER = 54, DIFI = 6.961D-04 1.205D-03 4.977D-03 4.375D-02 2.333D-02 1.557D-02 4.620D-02 1.250D-03
 K =1, I = 1, S = 0.0 , NITER = 55, DIFI = 6.296D-04 8.555D-04 4.398D-03 3.306D-02 1.774D-02 1.251D-02 3.816D-02 1.028D-03
 K =1, I = 1, S = 0.0 , NITER = 56, DIFI = 4.270D-04 7.891D-04 2.875D-03 2.665D-02 1.435D-02 9.502D-03 2.712D-02 7.238D-04
 K =1, I = 1, S = 0.0 , NITER = 57, DIFI = 3.808D-04 5.428D-04 2.572D-03 1.998D-02 1.085D-02 7.557D-03 2.295D-02 5.993D-04
 K =1, I = 1, S = 0.0 , NITER = 58, DIFI = 2.558D-04 4.969D-04 1.673D-03 1.606D-02 8.729D-03 5.743D-03 1.575D-02 4.232D-04
 K =1, I = 1, S = 0.0 , NITER = 59, DIFI = 2.238D-04 3.396D-04 1.516D-03 1.199D-02 6.565D-03 4.561D-03 1.354D-02 3.541D-04
 K =1, I = 1, S = 0.0 , NITER = 60, DIFI = 1.496D-04 3.118D-04 9.803D-04 9.610D-03 5.264D-03 3.449D-03 9.040D-03 2.495D-04

UINF PINF TINF CAINF TB BRAD PR LE YSH ALT
 0.251D 05 0.53938D-01 0.36148D 03 0.0 0.2460D 04 0.2361D 01 0.70D 00 0.14D 01 0.5730D-01 0.245D 06

THIN SHOCK LAYER NO WALL SLIP NC SHOCK SLIP CAT WALL NO STEPS IN Y= 51 NO STEPS IN S= 6 S STEP SIZE=0.200

TW/TS EPS REYINF REYSH TREF UREF RREF PREF ITER
 0.0744 0.0674 0.1433D 05 0.6568D 03 0.1045D 06 0.2510D 05 0.8673D-07 0.5464D 02 1

**** FREE FLIGHT HYPERBOLOID ALT=245K FT. M=26.9 ALPHA=30, 7-SPECIES

S X R YSH YSHP XSH RSH NO ITER NITTOT NTOT I K
 0.0 0.0 0.0 0.057298 0.0 -0.057298 0.0 60 60 60 1 1

DS CF HEAT STAN CDF CDP CDTOT PWALL TWALL PW/PO
 0.200000 0.0 0.035446 0.074147 0.0 1.776036 1.776036 0.888018 2460.000000 1.000000

YSHP (S YSHP (S+DS/2 NEW YSHP ALPHA(S+DS/2 PHI(S+DS/2 KAPPA(S KAPPA(S+DS/2
 0.0 0.000000 0.0 1.471372 1.471372 1.000000 0.981643

USH VSH TSH RSH PSH VPG
 0.0 -0.099835 0.313485 9.967057 0.891793 0.0
 0.0 -2505.86 32762.80 18201.56

N	Y/YSH	U/USH	V/VSH	T/TSH	R/RSH	P/PSH(APPR)	P/PSH	CA	CAEQ	XM	T DEG R
1	0.0	0.0	0.0	0.075085	13.261843	0.995768	1.059935	0.0	0.000002	0.0	2460.00
2	0.004777	0.044398	0.000120	0.117487	8.191109	0.995768	1.059935	0.035481	0.007009	0.000113	3849.20
3	0.009792	0.080532	0.000553	0.150773	6.210330	0.995769	1.059936	0.064107	0.150073	0.000458	4939.76
4	0.015059	0.112365	0.001300	0.179252	5.100603	0.995770	1.059938	0.088580	0.603878	0.000979	5872.80
5	0.020588	0.141459	0.002366	0.204449	4.376505	0.995773	1.059939	0.109923	0.912136	0.001655	6698.31
6	0.026394	0.168627	0.003758	0.227086	3.862194	0.995777	1.059941	0.128647	0.980755	0.002474	7439.96
7	0.032491	0.194355	0.005487	0.247565	3.476608	0.995781	1.059942	0.145055	0.994337	0.003432	8110.93
8	0.038892	0.218960	0.007562	0.266144	3.176490	0.995787	1.059943	0.159357	0.997847	0.004528	8719.61
9	0.045614	0.242659	0.009994	0.283006	2.936348	0.995794	1.059942	0.171725	0.999009	0.005764	9272.06
10	0.052671	0.265605	0.012796	0.298302	2.740011	0.995801	1.059940	0.182315	0.999474	0.007143	9773.22
11	0.060081	0.287906	0.015980	0.312170	2.576642	0.995811	1.059936	0.191284	0.999689	0.008671	10227.55
12	0.067862	0.309639	0.019563	0.324736	2.438672	0.995822	1.059929	0.198793	0.999799	0.010356	10639.25
13	0.076032	0.330856	0.023560	0.336124	2.320634	0.995834	1.059918	0.205005	0.999862	0.012204	11012.36
14	0.084610	0.351589	0.027993	0.346453	2.218485	0.995848	1.059903	0.210085	0.999900	0.014225	11350.76
15	0.093617	0.371858	0.032881	0.355837	2.129165	0.995864	1.059883	0.214190	0.999924	0.016429	11658.20
16	0.103075	0.391672	0.038248	0.364384	2.050326	0.995881	1.059857	0.217472	0.999940	0.018825	11938.25
17	0.113006	0.411031	0.044120	0.372199	1.980150	0.995901	1.059822	0.220066	0.999952	0.021424	12194.28
18	0.123433	0.429929	0.050522	0.379375	1.917217	0.995923	1.059779	0.222097	0.999960	0.024236	12429.38
19	0.134381	0.448361	0.057481	0.385998	1.860415	0.995948	1.059724	0.223669	0.999966	0.027274	12646.36
20	0.145877	0.466320	0.065026	0.392144	1.808875	0.995975	1.059657	0.224874	0.999971	0.030548	12847.74
21	0.157947	0.483802	0.073185	0.397883	1.761912	0.996005	1.059575	0.225786	0.999975	0.034068	13035.76
22	0.170621	0.500808	0.081985	0.403273	1.718987	0.996038	1.059475	0.226467	0.999978	0.037847	13212.37
23	0.183929	0.517349	0.091452	0.408368	1.679677	0.996074	1.059356	0.226967	0.999980	0.041894	13379.27
24	0.197902	0.533443	0.101614	0.413213	1.643640	0.996113	1.059214	0.227324	0.999982	0.046219	13538.00
25	0.212574	0.549121	0.112497	0.417849	1.610600	0.996156	1.059046	0.227567	0.999984	0.050830	13689.91
26	0.227983	0.564425	0.124125	0.422316	1.580325	0.996202	1.058848	0.227720	0.999985	0.055743	13836.26
27	0.244155	0.579408	0.136527	0.426649	1.552610	0.996253	1.058617	0.227798	0.999987	0.060968	13978.23
28	0.261140	0.594137	0.149730	0.430885	1.527267	0.996308	1.058348	0.227814	0.999988	0.066517	14116.99
29	0.278974	0.608686	0.163767	0.435059	1.504111	0.996368	1.058036	0.227775	0.999989	0.072404	14253.74
30	0.297699	0.623140	0.178676	0.439209	1.482955	0.996432	1.057676	0.227685	0.999990	0.078645	14389.73
31	0.317361	0.637586	0.194504	0.443379	1.463600	0.996502	1.057262	0.227548	0.999990	0.085257	14526.32
32	0.338006	0.652116	0.211305	0.447611	1.445831	0.996578	1.056785	0.227362	0.999991	0.092264	14665.00
33	0.359683	0.666817	0.229151	0.451958	1.429416	0.996661	1.056238	0.227126	0.999992	0.099687	14807.41
34	0.382443	0.681773	0.248127	0.456476	1.414100	0.996750	1.055610	0.226836	0.999992	0.107554	14955.43
35	0.406342	0.697061	0.268337	0.461229	1.399609	0.996847	1.054888	0.226487	0.999993	0.115913	15111.16
36	0.431436	0.712748	0.289908	0.466293	1.385650	0.996952	1.054093	0.226072	0.999994	0.124807	15277.07
37	0.457785	0.728890	0.312991	0.471755	1.371918	0.997066	1.053103	0.225580	0.999994	0.134291	15456.01
38	0.485451	0.745533	0.337766	0.477721	1.358091	0.997190	1.052000	0.224995	0.999995	0.144426	15651.46
39	0.514500	0.762709	0.364444	0.484320	1.343837	0.997324	1.050724	0.224287	0.999995	0.155286	15867.68
40	0.545002	0.780442	0.393279	0.491720	1.328805	0.997470	1.049242	0.223461	0.999996	0.166958	16110.11
41	0.577029	0.798740	0.424574	0.500138	1.312614	0.997628	1.047514	0.222442	0.999996	0.179567	16385.92
42	0.610657	0.817602	0.458705	0.509873	1.294836	0.997800	1.045493	0.221184	0.999997	0.193227	16704.88
43	0.645966	0.837010	0.496148	0.521351	1.274951	0.997986	1.043114	0.219600	0.999997	0.208087	17080.93
44	0.683041	0.856930	0.537543	0.535204	1.252293	0.998186	1.040293	0.217559	0.999997	0.224356	17534.78
45	0.721970	0.877301	0.583786	0.552415	1.225958	0.998403	1.036914	0.214848	0.999998	0.242336	18098.65
46	0.762845	0.898030	0.636188	0.574585	1.194711	0.998634	1.032809	0.211088	0.999998	0.262657	18825.03
47	0.805764	0.918976	0.696704	0.604456	1.156925	0.998881	1.027733	0.205480	0.999999	0.286385	19803.68
48	0.850829	0.939927	0.768120	0.646967	1.110841	0.999142	1.021351	0.196027	0.999999	0.315260	21196.44
49	0.908143	0.960592	0.853243	0.711490	1.056246	0.999416	1.013441	0.176912	0.999999	0.353212	23310.40
50	0.947832	0.980636	0.947414	0.816436	1.002283	0.999699	1.005289	0.129755	1.000000	0.406458	26748.73
51	1.000000	1.000000	0.999512	1.000000	1.000000	1.000000	1.000000	0.0	1.000000	0.456962	32762.80

N	Y/RN	C	Q2	NO	N	NO+	N2	E-/CC	Y IN	Y CM
1	0.0	0.0	0.23456D 00	0.0	0.0	0.0	0.76544D 00	0.0	0.0	0.0
2	0.00027	0.35481D-01	0.19169D 00	0.14123D-01	0.27265D-02	0.33959D-04	0.75594D 00	0.24877D 13	0.00775	0.01969
3	0.00056	0.64167D-01	0.15748D 00	0.24815D-01	0.55919D-02	0.63296D-04	0.74794D 00	0.35156D 13	0.01590	0.04037
4	0.00086	0.88580D-01	0.12877D 00	0.32958D-01	0.91067D-02	0.91367D-04	0.74049D 00	0.41680D 13	0.02444	0.06209
5	0.00118	0.10992D 00	0.10434D 00	0.38925D-C1	0.13523D-01	0.11953D-03	0.73317D 00	0.46785D 13	0.03342	0.08489
6	0.00151	0.12965D 00	0.83544D-01	0.42958D-C1	0.18994D-01	0.14855D-03	0.72571D 00	0.51312D 13	0.04285	0.10883
7	0.00186	0.14505D 00	0.65977D-01	0.45268D-01	0.25614D-01	0.17898D-03	0.71791D 00	0.55651D 13	0.05274	0.13396
8	0.00223	0.15936D 00	0.51309D-01	0.46074D-C1	0.33432D-01	0.21125D-03	0.7062D 00	0.60015D 13	0.06313	0.16036
9	0.00261	0.17172D 00	0.39246D-01	0.45604D-01	0.42451D-01	0.24572D-03	0.70073D 00	0.64529D 13	0.07404	0.18807
10	0.00302	0.18231D 00	0.29499D-01	0.44104D-C1	0.52641D-01	0.28267D-03	0.69116D 00	0.69270D 13	0.08550	0.21717
11	0.00344	0.19128D 00	0.21777D-01	0.41823D-01	0.63937D-01	0.32233D-03	0.68086D 00	0.74278D 13	0.09753	0.24772
12	0.00389	0.19879D 00	0.15790D-01	0.39007D-C1	0.76249D-01	0.36483D-03	0.66980D 00	0.79571D 13	0.11016	0.27980
13	0.00436	0.20501D 00	0.11250D-01	0.35882D-01	0.89466D-01	0.41022D-03	0.65799D 00	0.85141D 13	0.12342	0.31349
14	0.00485	0.21008D 00	0.78886D-02	0.32650D-C1	0.10346D 00	0.45848D-03	0.64546D 00	0.90969D 13	0.13734	0.34885
15	0.00536	0.21419D 00	0.54582D-02	0.29475D-C1	0.11809D 00	0.50949D-03	0.63228D 00	0.97019D 13	0.15197	0.38599
16	0.00591	0.21747D 00	0.37424D-02	0.26482D-C1	0.13322D 00	0.56303D-03	0.61852D 00	0.10324D 14	0.16732	0.42499
17	0.00648	0.22007D 00	0.25594D-02	0.23757D-C1	0.14869D 00	0.61884D-03	0.60431D 00	0.10960D 14	0.18344	0.46593
18	0.00707	0.22210D 00	0.17616D-02	0.21349D-C1	0.16436D 00	0.67659D-03	0.58975D 00	0.11601D 14	0.20036	0.50892
19	0.00770	0.22367D 00	0.12344D-02	0.19273D-C1	0.18008D 00	0.73590D-03	0.57501D 00	0.12245D 14	0.21813	0.55406
20	0.00836	0.22487D 00	0.89166D-03	0.17525D-01	0.19570D 00	0.79635D-03	0.56022D 00	0.12883D 14	0.23680	0.60146
21	0.00905	0.22579D 00	0.67162D-03	0.16080D-C1	0.21106D 00	0.85752D-03	0.54554D 00	0.13513D 14	0.25639	0.65123
22	0.00978	0.22647D 00	0.53116D-03	0.14908D-01	0.22602D 00	0.91899D-03	0.53115D 00	0.14129D 14	0.27696	0.70348
23	0.01054	0.22667D 00	0.44140D-03	0.13971D-C1	0.24044D 00	0.98033D-03	0.51720D 00	0.14727D 14	0.29856	0.75835
24	0.01134	0.22732D 00	0.38362D-03	0.13236D-01	0.25417D 00	0.10411D-02	0.50384D 00	0.15305D 14	0.32125	0.81597
25	0.01218	0.22757D 00	0.34602D-03	0.12671D-01	0.26707D 00	0.11011D-02	0.49124D 00	0.15860D 14	0.34506	0.87646
26	0.01306	0.22772D 00	0.32141D-03	0.12249D-C1	0.27902D 00	0.11598D-02	0.47954D 00	0.16392D 14	0.37007	0.93998
27	0.01399	0.22780D 00	0.30552D-03	0.11951D-01	0.28988D 00	0.12170D-02	0.46885D 00	0.16900D 14	0.39633	1.00667
28	0.01496	0.22781D 00	0.29586D-03	0.11761D-C1	0.29556D 00	0.12727D-02	0.45930D 00	0.17384D 14	0.42390	1.07670
29	0.01598	0.22777D 00	0.29107D-03	0.11672D-C1	0.30796D 00	0.13265D-02	0.45097D 00	0.17845D 14	0.45285	1.15023
30	0.01706	0.22769D 00	0.29041D-03	0.11677D-C1	0.31504D 00	0.13786D-02	0.44393D 00	0.18284D 14	0.48324	1.22744
31	0.01818	0.22755D 00	0.29358D-03	0.11775D-C1	0.32073D 00	0.14289D-02	0.43822D 00	0.18704D 14	0.51516	1.30850
32	0.01937	0.22736D 00	0.30054D-03	0.11967D-01	0.32504D 00	0.14777D-02	0.43385D 00	0.19108D 14	0.54867	1.39362
33	0.02061	0.22713D 00	0.31145D-03	0.12257D-C1	0.32799D 00	0.15251D-02	0.43079D 00	0.19497D 14	0.58386	1.48300
34	0.02191	0.22684D 00	0.32667D-03	0.12652D-01	0.32960D 00	0.15714D-02	0.42901D 00	0.19874D 14	0.62080	1.57684
35	0.02328	0.22649D 00	0.34671D-03	0.13161D-C1	0.32996D 00	0.16170D-02	0.42843D 00	0.20240D 14	0.65960	1.67538
36	0.02472	0.22607D 00	0.37236D-03	0.13796D-C1	0.32913D 00	0.16620D-02	0.42897D 00	0.20597D 14	0.70033	1.77884
37	0.02623	0.22558D 00	0.40468D-03	0.14574D-C1	0.32720D 00	0.17068D-02	0.43053D 00	0.20942D 14	0.74310	1.88748
38	0.02782	0.22499D 00	0.44521D-03	0.15518D-01	0.32426D 00	0.17510D-02	0.43303D 00	0.21268D 14	0.78801	2.00155
39	0.02948	0.22430D 00	0.49618D-03	0.16663D-01	0.32034D 00	0.17941D-02	0.43640D 00	0.21563D 14	0.83517	2.12132
40	0.03123	0.22346D 00	0.56092D-03	0.18054D-C1	0.31548D 00	0.18346D-02	0.44061D 00	0.21803D 14	0.88468	2.24708
41	0.03306	0.22244D 00	0.64467D-03	0.19759D-01	0.30964D 00	0.18697D-02	0.44565D 00	0.21949D 14	0.93667	2.37913
42	0.03499	0.22118D 00	0.75622D-03	0.21875D-C1	0.30269D 00	0.18947D-02	0.45160D 00	0.21941D 14	0.99125	2.51778
43	0.03701	0.21960D 00	0.91190D-03	0.24539D-01	0.29442D 00	0.19019D-02	0.45862D 00	0.21687D 14	1.04857	2.66337
44	0.03914	0.21756D 00	0.11465D-02	0.27942D-01	0.28446D 00	0.18800D-02	0.46701D 00	0.21056D 14	1.10875	2.81623
45	0.04137	0.21485D 00	0.15460D-02	0.32337D-C1	0.27219D 00	0.18129D-02	0.47726D 00	0.19878D 14	1.17194	2.97674
46	0.04371	0.21109D 00	0.23530D-02	0.38002D-01	0.25658D 00	0.16803D-02	0.49030D 00	0.17954D 14	1.23829	3.14527
47	0.04617	0.20548D 00	0.43128D-02	0.45057D-C1	0.23588D 00	0.14611D-02	0.50781D 00	0.15119D 14	1.30796	3.32223
48	0.04875	0.19603D 00	0.98198D-02	0.52766D-01	0.20715D 00	0.11428D-02	0.53310D 00	0.11354D 14	1.38112	3.50803
49	0.05146	0.17691D 00	0.26645D-01	0.57455D-01	0.16528D 00	0.73809D-03	0.57297D 00	0.69725D 13	1.45793	3.70313
50	0.05431	0.12976D 00	0.79327D-01	0.47501D-01	0.10154D 00	0.30985D-03	0.64157D 00	0.27775D 13	1.53858	3.90798
51	0.05730	0.0	0.23456D 00	0.0	0.0	0.0	0.76544D 00	0.0	1.62326	4.12307

K =1, I = 2, S = 0.200, NITER = 1, DIFI = 3.912D-02 5.392D-02 2.990D-02 4.413D-02 4.555D-02 6.885D-02 7.509D-02 4.763D-02
 K =1, I = 2, S = 0.200, NITER = 2, DIFI = 2.762D-02 1.550D-02 2.912D-02 2.836D-02 5.926D-02 2.639D-02 5.829D-02 1.163D-02
 K =1, I = 2, S = 0.200, NITER = 3, DIFI = 6.851D-03 5.341D-03 1.915D-02 2.903D-02 2.304D-02 1.811D-02 2.626D-02 1.144D-02
 K =1, I = 2, S = 0.200, NITER = 4, DIFI = 1.992D-03 3.587D-03 3.102D-03 7.073D-03 7.086D-03 3.781D-03 1.596D-02 9.245D-04

**** FREE FLIGHT HYPERBOLOID ALT=245K FT. M=26.9 ALPHA=30, 7-SPECIES

S	X	R	YSH	YSHP	XSH	RSH	NO ITER	NITTOT	NTOT	I	K
0.200000	0.019709	0.198780	0.059483	0.021851	-0.038643	0.210324	4	64	64	2	1
DS	CF	HEAT	STAN	CDF	CDP	CDTOT	PWALL	TWALL	PW/PO		
0.200000	0.013616	0.033625	0.070339	0.002658	1.665276	1.667934	0.843597	2460.000000	0.949977		
YSHP (S	YSHP (S+DS/2	NEW YSHP	ALPHA(S+DS/2	PHI(S+DS/2	KAPPA(S	KAPPA(S+DS/2					
0.000000	0.000000	0.021851	1.286004	1.286004	0.930449	0.856159					
USH	VSH	TSH	RSH	PSH	VPG						
0.190109	-0.099149	0.305478	9.857033	0.859673	0.0						
4771.75	-2488.64	31925.95									
		17736.65									

126

K =1, I = 3, S = 0.400, NITER = 1, DIFI = 7.504D-02 8.836D-02 8.205D-02 1.429D-01 1.228D-01 2.003D-01 1.899D-01 1.158D-01
 K =1, I = 3, S = 0.400, NITER = 2, DIFI = 5.094D-02 4.144D-02 5.423D-02 8.857D-02 1.634D-01 5.909D-02 1.765D-01 2.668D-02
 K =1, I = 3, S = 0.400, NITER = 3, DIFI = 2.282D-02 1.548D-02 3.568D-02 5.958D-02 4.728D-02 2.923D-02 6.188D-02 1.858D-02
 K =1, I = 3, S = 0.400, NITER = 4, DIFI = 2.834D-03 5.003D-03 4.085D-03 1.332D-02 1.347D-02 8.661D-03 2.194D-02 1.600D-03
 K =1, I = 3, S = 0.400, NITER = 5, DIFI = 6.926D-04 6.443D-04 4.402D-03 3.919D-03 6.491D-03 2.995D-03 1.236D-02 2.920D-03

**** FREE FLIGHT HYPERBOLOID ALT=245K FT. M=26.9 ALPHA=30, 7-SPECIES

S	X	R	YSH	YSHP	XSH	RSH	NO ITER	NITTOT	NTOT	I	K
0.400000	0.075579	0.390592	0.066038	0.043701	0.013918	0.414237	5	69	69	3	1
DS	CF	HEAT	STAN	CDF	CDP	CDTOT	PWALL	TWALL	PW/PO		
0.200000	0.022658	0.029178	0.061036	0.005531	1.569058	1.574589	0.738811	2460.000000	0.831977		
YSHP (S	YSHP (S+DS/2	NEW YSHP	ALPHA(S+DS/2	PHI(S+DS/2	KAPPA(S	KAPPA(S+DS/2					
0.000000	0.000000	0.043701	1.132012	1.132012	0.770250	0.682420					
USH	VSH	TSH	RSH	PSH	VPG						
0.352899	-0.097389	0.285411	9.573061	0.780431	0.0						
8857.76	-2444.46	25828.70									
		16571.50									

N	Y/YSH	U/USH	V/VSH	T/TSH	R/RSR	P/PSH(APPR)	P/PSH	CA	CAEQ	XM	T DEG R
1	0.0	0.0	0.0	0.109400	7.735541	0.843976	0.900964	0.0	0.000004	0.0	2465.10
2	0.004777	0.045377	0.000117	0.166077	4.950164	0.843982	0.900970	0.030088	0.006533	0.274894	3742.18
3	0.009792	0.083085	0.000536	0.210122	3.820344	0.844004	0.900993	0.054964	0.130814	0.446973	4734.65
4	0.015059	0.116797	0.001265	0.247439	3.176770	0.844049	0.901040	0.076726	0.545970	0.575939	5575.52
5	0.020588	0.147983	0.002313	0.280210	2.752112	0.844118	0.901112	0.096163	0.883606	0.681070	6313.94
6	0.026394	0.177413	0.003698	0.309485	2.447904	0.844215	0.901212	0.113649	0.973406	0.771418	6973.58
7	0.032491	0.205549	0.005433	0.335849	2.218337	0.844342	0.901342	0.129381	0.992178	0.851868	7567.64
8	0.038892	0.232691	0.007537	0.359665	2.038805	0.844501	0.901506	0.143474	0.997055	0.925466	8104.29
9	0.045614	0.259043	0.010027	0.381184	1.894734	0.844695	0.901704	0.156008	0.998659	0.994124	8589.18
10	0.052671	0.284746	0.012921	0.400596	1.776854	0.844928	0.901942	0.167051	0.999294	1.059334	9026.58
11	0.060081	0.309898	0.016239	0.418061	1.678925	0.845203	0.902221	0.176672	0.999585	1.122034	9420.12
12	0.067862	0.334567	0.020003	0.433729	1.596557	0.845525	0.902547	0.184954	0.999733	1.182870	9773.16
13	0.076032	0.358792	0.024237	0.447746	1.526549	0.845897	0.902922	0.191988	0.999816	1.242309	10089.00
14	0.084610	0.382594	0.028965	0.460258	1.466500	0.846326	0.903352	0.197880	0.999866	1.300628	10370.94
15	0.093617	0.405977	0.034216	0.471415	1.414567	0.846816	0.903842	0.202745	0.999897	1.357968	10622.34
16	0.103075	0.428930	0.040023	0.481368	1.369308	0.847373	0.904396	0.206698	0.999918	1.414364	10846.61
17	0.113006	0.451435	0.046419	0.490268	1.329579	0.848003	0.905020	0.209857	0.999933	1.469775	11047.16
18	0.123433	0.473461	0.053440	0.498265	1.294469	0.848714	0.905719	0.212333	0.999944	1.524149	11227.34
19	0.134381	0.494976	0.061127	0.505503	1.263243	0.849510	0.906498	0.214229	0.999952	1.577364	11390.43
20	0.145877	0.515946	0.069519	0.512118	1.235317	0.850401	0.907364	0.215635	0.999958	1.629290	11539.50
21	0.157947	0.536337	0.078657	0.518239	1.210226	0.851392	0.908321	0.216631	0.999963	1.679809	11677.41
22	0.170621	0.556125	0.088582	0.523977	1.187605	0.852491	0.909375	0.217282	0.999967	1.728827	11806.71
23	0.183929	0.575292	0.099334	0.529434	1.167173	0.853707	0.910531	0.217643	0.999970	1.776297	11929.67
24	0.197902	0.593833	0.110950	0.534696	1.148718	0.855046	0.911794	0.217757	0.999973	1.822216	12048.23
25	0.212574	0.611759	0.123464	0.539835	1.132081	0.856519	0.913169	0.217656	0.999975	1.866623	12164.05
26	0.227980	0.629098	0.136911	0.544913	1.117145	0.858133	0.914663	0.217368	0.999978	1.909652	12278.46
27	0.244155	0.645893	0.151319	0.549979	1.103824	0.859900	0.916282	0.216910	0.999979	1.951466	12392.61
28	0.261140	0.662201	0.166719	0.555074	1.092049	0.861829	0.918030	0.216298	0.999981	1.992268	12507.41
29	0.278374	0.678095	0.183141	0.560232	1.081759	0.863933	0.919917	0.215543	0.999983	2.032290	12623.65
30	0.297699	0.693653	0.200618	0.565487	1.072894	0.866225	0.921949	0.214655	0.999984	2.071772	12742.04
31	0.317361	0.708956	0.219187	0.570867	1.065386	0.868721	0.924135	0.213641	0.999985	2.110949	12863.27
32	0.338006	0.724085	0.238895	0.576403	1.059153	0.871437	0.926485	0.212508	0.999986	2.150028	12988.02
33	0.359683	0.739112	0.259798	0.582130	1.054098	0.874393	0.929009	0.211263	0.999987	2.189174	13117.08
34	0.382443	0.754100	0.281965	0.588087	1.050110	0.877608	0.931718	0.209910	0.999988	2.228497	13251.29
35	0.406342	0.769095	0.305480	0.594317	1.047058	0.881107	0.934622	0.208451	0.999989	2.268048	13391.67
36	0.431436	0.784131	0.330443	0.600872	1.044805	0.884914	0.937731	0.206886	0.999990	2.307749	13539.38
37	0.457785	0.799226	0.356970	0.607815	1.043205	0.889356	0.941056	0.205208	0.999991	2.347435	13695.81
38	0.485451	0.814381	0.385194	0.615217	1.042112	0.893564	0.944604	0.203405	0.999992	2.387220	13862.60
39	0.514500	0.829588	0.415266	0.623167	1.041382	0.898467	0.948379	0.201458	0.999993	2.426978	14041.74
40	0.545002	0.844827	0.447357	0.631776	1.040875	0.903800	0.952384	0.199334	0.999993	2.466565	14235.73
41	0.577029	0.860067	0.481666	0.641190	1.040448	0.909595	0.956613	0.196987	0.999994	2.505820	14447.85
42	0.610657	0.875272	0.518428	0.651606	1.039936	0.915890	0.961055	0.194355	0.999995	2.544568	14682.57
43	0.645966	0.890394	0.557941	0.663312	1.039133	0.922720	0.965685	0.191353	0.999995	2.582159	14946.33
44	0.683041	0.905381	0.600599	0.676731	1.037746	0.930121	0.970457	0.187866	0.999996	2.618825	15248.69
45	0.721970	0.920171	0.646947	0.692514	1.035349	0.938127	0.975298	0.183728	0.999996	2.654758	15604.33
46	0.762845	0.934691	0.697768	0.711691	1.031321	0.946767	0.980082	0.178648	0.999997	2.690201	16036.45
47	0.805764	0.948854	0.754165	0.735939	1.024828	0.956061	0.984616	0.171982	0.999998	2.727327	16582.82
48	0.850829	0.962561	0.817559	0.768108	1.014973	0.966017	0.988629	0.162011	0.999998	2.767447	17307.68
49	0.898148	0.975697	0.889089	0.813435	1.001603	0.976628	0.991894	0.143769	0.999999	2.817515	18329.04
50	0.947832	0.988163	0.966070	0.882724	0.988699	0.978900	0.995098	0.102744	0.999999	2.908442	19890.30
51	1.000000	1.000000	1.023879	1.000000	1.000000	1.000000	1.000000	0.0	0.999999	3.113401	22532.88

N	Y/RN	O	O2	NJ	N	NO+	N2	E-/CC	Y IN	Y CM
1	0.0	0.0	0.234560 00	0.0	0.0	0.0	0.765440 00	0.0	0.0	0.0
2	0.00055	0.300880-01	0.197230 00	0.115830-01	0.166720-02	0.224980-04	0.759410 00	0.860450 12	0.01563	0.03970
3	0.00113	0.549640-01	0.166590 00	0.207030-01	0.341260-02	0.420010-04	0.754290 00	0.123970 13	0.03204	0.08138
4	0.00174	0.767260-01	0.140130 00	0.279950-01	0.555120-02	0.605260-04	0.749540 00	0.148560 13	0.04927	0.12514
5	0.00238	0.961630-01	0.116910 00	0.336680-01	0.826280-02	0.789200-04	0.744890 00	0.167810 13	0.06736	0.17110
6	0.00305	0.113650 00	0.964910-01	0.378980-01	0.116770-01	0.976710-04	0.740190 00	0.184720 13	0.08636	0.21935
7	0.00375	0.129380 00	0.786140-01	0.407160-01	0.158930-01	0.117120-03	0.735280 00	0.200740 13	0.10630	0.27001
8	0.00449	0.143470 00	0.631150-01	0.422350-01	0.209850-01	0.137550-03	0.730050 00	0.216670 13	0.12725	0.32321
9	0.00527	0.156010 00	0.498580-01	0.425740-01	0.265970-01	0.159180-03	0.724400 00	0.233020 13	0.14924	0.37907
10	0.00608	0.167050 00	0.386990-01	0.418750-01	0.339490-01	0.182200-03	0.718240 00	0.250130 13	0.17233	0.43772
11	0.00694	0.176670 00	0.294810-01	0.403080-01	0.418290-01	0.206770-03	0.711500 00	0.268220 13	0.19657	0.49930
12	0.00784	0.184950 00	0.220220-01	0.380620-01	0.505960-01	0.232990-03	0.704130 00	0.287400 13	0.22203	0.56396
13	0.00878	0.191990 00	0.161210-01	0.353360-01	0.601840-01	0.260920-03	0.696110 00	0.307740 13	0.24876	0.63186
14	0.00977	0.197880 00	0.115630-01	0.323250-01	0.705020-01	0.290550-03	0.687440 00	0.329210 13	0.27683	0.70315
15	0.01081	0.202740 00	0.813120-02	0.292140-01	0.814350-01	0.321830-03	0.678150 00	0.351730 13	0.30630	0.77800
16	0.01190	0.206700 00	0.561460-02	0.261590-01	0.928550-01	0.354630-03	0.668320 00	0.375180 13	0.33724	0.85660
17	0.01305	0.209860 00	0.381840-02	0.232880-01	0.104620 00	0.388770-03	0.658030 00	0.399360 13	0.36973	0.93912
18	0.01426	0.212330 00	0.257130-02	0.206890-01	0.116560 00	0.424020-03	0.647420 00	0.424080 13	0.40385	1.02578
19	0.01552	0.214230 00	0.172870-02	0.184200-01	0.128530 00	0.460130-03	0.636630 00	0.449090 13	0.43967	1.11676
20	0.01685	0.215640 00	0.117450-02	0.165020-01	0.140350 00	0.496800-03	0.625840 00	0.474160 13	0.47728	1.21230
21	0.01824	0.216630 00	0.819050-03	0.149340-01	0.151860 00	0.533720-03	0.615220 00	0.499050 13	0.51677	1.31261
22	0.01970	0.217280 00	0.596350-03	0.136960-01	0.162880 00	0.570570-03	0.604970 00	0.523530 13	0.55824	1.41793
23	0.02124	0.217640 00	0.459770-03	0.127540-01	0.173250 00	0.607040-03	0.595290 00	0.547410 13	0.60178	1.52853
24	0.02286	0.217760 00	0.377750-03	0.120730-01	0.182790 00	0.642830-03	0.586360 00	0.570520 13	0.64750	1.64465
25	0.02455	0.217660 00	0.329790-03	0.116180-01	0.191370 00	0.677650-03	0.578350 00	0.592710 13	0.69550	1.76658
26	0.02633	0.217370 00	0.303110-03	0.113560-01	0.198830 00	0.711240-03	0.571430 00	0.613890 13	0.74591	1.89461
27	0.02820	0.216910 00	0.290100-03	0.112620-01	0.205050 00	0.743370-03	0.565740 00	0.633970 13	0.79883	2.02903
28	0.03016	0.216300 00	0.286420-03	0.113200-01	0.209940 00	0.773840-03	0.561380 00	0.652910 13	0.85440	2.17018
29	0.03222	0.215540 00	0.289830-03	0.115170-01	0.213430 00	0.802470-03	0.558420 00	0.670690 13	0.91275	2.31839
30	0.03438	0.214650 00	0.299320-03	0.118520-01	0.215460 00	0.829140-03	0.556910 00	0.687310 13	0.97402	2.47400
31	0.03665	0.213640 00	0.314690-03	0.123250-01	0.216040 00	0.853760-03	0.556830 00	0.702760 13	1.03835	2.63740
32	0.03904	0.212510 00	0.336330-03	0.129460-01	0.215190 00	0.876250-03	0.558140 00	0.717050 13	1.10589	2.80897
33	0.04154	0.211260 00	0.365060-03	0.137290-01	0.212980 00	0.896570-03	0.560760 00	0.730180 13	1.17682	2.98911
34	0.04417	0.209910 00	0.402170-03	0.146930-01	0.209510 00	0.914670-03	0.564570 00	0.742100 13	1.25129	3.17826
35	0.04693	0.208450 00	0.449450-03	0.158640-01	0.204890 00	0.930480-03	0.569420 00	0.752740 13	1.32948	3.37687
36	0.04983	0.206890 00	0.509380-03	0.172770-01	0.199240 00	0.943830-03	0.575140 00	0.761890 13	1.41158	3.58541
37	0.05287	0.205210 00	0.585340-03	0.189740-01	0.192710 00	0.954390-03	0.581570 00	0.769230 13	1.49779	3.80438
38	0.05606	0.203410 00	0.682050-03	0.210110-01	0.185420 00	0.961580-03	0.588520 00	0.774220 13	1.58831	4.03430
39	0.05942	0.201460 00	0.606180-03	0.234590-01	0.177460 00	0.964460-03	0.595850 00	0.775990 13	1.68335	4.27571
40	0.06294	0.199330 00	0.967550-03	0.264070-01	0.168920 00	0.961580-03	0.603410 00	0.773300 13	1.78315	4.52919
41	0.06664	0.196990 00	0.118140-02	0.299650-01	0.155820 00	0.950800-03	0.611090 00	0.764320 13	1.88793	4.79535
42	0.07052	0.194360 00	0.147300-02	0.342600-01	0.150170 00	0.929160-03	0.618810 00	0.746550 13	1.99796	5.07481
43	0.07460	0.191350 00	0.188950-02	0.394280-01	0.139900 00	0.892790-03	0.626540 00	0.716780 13	2.11348	5.36825
44	0.07888	0.187870 00	0.252780-02	0.455720-01	0.128870 00	0.837020-03	0.634330 00	0.671110 13	2.23479	5.67636
45	0.08338	0.183730 00	0.360900-02	0.526800-01	0.116870 00	0.756980-03	0.642360 00	0.605530 13	2.36215	5.99987
46	0.08810	0.178650 00	0.567160-02	0.604190-01	0.103520 00	0.648940-03	0.651090 00	0.517390 13	2.49589	6.33956
47	0.09306	0.171980 00	0.100680-01	0.677060-01	0.883080-01	0.512950-03	0.661420 00	0.406150 13	2.63631	6.69624
48	0.09826	0.162010 00	0.202000-01	0.718570-01	0.705990-01	0.356360-03	0.674980 00	0.279460 13	2.78376	7.07075
49	0.10373	0.143770 00	0.444320-01	0.672790-01	0.498570-01	0.197410-03	0.694470 00	0.152760 13	2.93857	7.46398
50	0.10946	0.102740 00	0.102470 00	0.448870-01	0.261470-01	0.661200-04	0.723680 00	0.505080 12	3.10113	7.87688
51	0.11549	0.0	0.234560 00	0.0	0.0	0.0	0.765440 00	0.0	3.27182	8.31042

APPENDIX C: FORTRAN IV PROGRAM

This appendix gives a list of the program common statements, a listing of the common statements as they occur by subroutines and a complete listing of the FORTRAN IV source statements for PROGRAM VISLNABB.

List of Common Statements

```

COMMON /BODY/ HANGLE,XJFAC,IGEGM,JFAC
COMMON /COMABZ/ ALPHSB(15,11),BETASB(15,11),ZSUB(5,6),ALSUB(15),BE
1TSUB(15),GAMMMI(15,6),GAMMPL(15,6)
COMMON /COMARL/ XNSP(202),XSOL(200)
COMMON /COMAR1/ AA(51),BB(51),CAEQ(51),CON(51),CO1(51),CO2(51),CPS
1T(51),EMBAR(51),PC(51),PCN(51),PE(51),PFAC(51),PS(51),PO(51),PON(5
21),PI(51),PIN(51),P2(51),P2N(51),Q1(51),Q2(51),RC(51),RCON(51),RCS
3F(51),RNSH(51),RVISC(51),R1(51),R2(51),TC(51),T1(51),T2(51),T20(51
4),T21(51),UC(51),UCN(51),UC1(51),U1(51),U2(51),U20(51),VC(51),VCD(
551),VCI1(51),VCI2(51),VG(51),VGN(51),VGS(51),VISC(51),VS(51),VO(51
6),VON(51),V1(51),V2(51),V2N(51)
COMMON /COMBC/ CAINF,CAW,CINF6(6),CIWW6(6)
COMMON /COMDBL/ AJB(51,6),AJM(51,6),CC(51,6),CCL(51,6),CCN(51,6),C
1PI(51,6),C1(51,6),C2(51,6),C20(51,6),DW(51,6),HI(51,6),WO(51,6),W1
2(51,6)
COMMON /COMEDG/ CIE(6),TCIE
COMMON /COMEL/ ELN(6),ELO(6)
COMMON /COMFAC/ CCFAC,UFAC
COMMON /COMFS/ PINF,REYIN,RINF,TINF,UNIF
COMMON /COMFSA/ CINF(6),CPIFS(6),DELHIF(6),HINF(6)
COMMON /COMG/ CAT,CNS,CRNI,REFAC,SSFAC,SWFAC,THIN,VPG,I,K,NITER
COMMON /COMG1/ CP,CPB,SP,SPB
COMMON /COMG2/ CK,CK2,CSF2,RS2,SIF2,X82,XNSPM
COMMON /COMG3/ CSF,RS,SIF,XB,XNS1
COMMON /COMNS/ NS
COMMON /COMNS2/ NJ,NR,NSM1,NZ
COMMON /COMPRF/ SPRF(10),NSPRF
COMMON /COMREF/ CONREF,CPREF,HREF,PREF,RREF,TREF,UREF,VSREF,WREF
COMMON /COMRX/ RSH,XSH
COMMON /COMSET/ RATE2(15,6),RATE6(15,6),ZSUB2(5,6),ZSUB6(5,6),KRTI
1TL(18),KREQ2(15,6),NAME2(11),NJ2,NR2,NZ2,KREQ6(15,6),NAME6(11),NJ6
2,NR6,NZ6
COMMON /COMSML/ SMALLT
COMMON /COMSUM/ CPJSUM(51),HDWSUM(51),HWSUM(51),HJSUMW
COMMON /COMSO/ PPSO,TTSO,VVSO,UUSO,NSOLD
COMMON /COMTAB/ CPTAB(50,6),HTAB(50,6),TMPTAB(50),NTAB
COMMON /COMTST/ DIFI(8),DIF,XU25
COMMON /COMUV/ URSH,VRSH
COMMON /COMVS/ EMI(6),VSA(6),VSB(6),VSC(6),R,NSPI(6)
COMMON /COMVSP/ VSPPI,VSPPI2
COMMON /COMW/ CIW(6),CIWW(6),CPIW(6),HIW(6),HTFLB,TB,TCNW,TW
COMMON /COMXR/ ALP,ALT,BRAD,B0,CDF,CDFD,CDF1,CDF2,CDP,CDPD,CDP1,CD
1P2,OLDSLP,PHI,SEND,WVFAC,XNSO,IEND,IUN,KPLTTP,NITMIN,NITOT,NTOT,N
2TPL,NTW
COMMON /INSH/ CONO,S,UPSH,XNS,EPS,TPSH,VISCO
COMMON /INV2/ XNSA,XNSIVO,XNSIV1,XNSTMP,NAN
COMMON /KJI/ IJK
COMMON /KNTR/ KNTR1,KNTW1,KNTW2
COMMON /OUTSH/ PPS,PPS1,PPS2,PSP,REYSH,RRS,RRS1,RRS2,RSP,TSP,TTS,T
1TS1,TTS2,USP,UUS,UUS1,UUS2,VSP,VVS,VVS1,VVS2
COMMON /PRLE/ SIGM,XLE
COMMON /RTECON/ CRO(15),CR1(15),CR2(15),DRO(15),DR1(15),DR2(15)
COMMON /SOLV/ A1(51),A2(51),A3(51),A4(51),DN(52),DS,XN(52),IE,IM
COMMON /TITLE/ KTITLE(20)

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Occurrence of Common Statements by Subroutines

A listing of the subroutines in which each common block occurs is given below. The listing used with the section "Description of Variables in Common" is an aid in determining where FORTRAN variables appear in the program.

<u>COMMON</u>	<u>OCCURS IN</u>									
BODY	ENERGY,	GEOM,	MAIN,	MASS,	SMOMNT,	SPECIE				
COMABZ	SET2,	WISUB								
COMARL	ENERGY,	MAIN,	MASS,	NMOMNT,	RESET,	SMOMNT,	SPECIE			
COMAR1	ENERGY,	MAIN,	MASS,	NMOMNT,	RESET,	SET,	SMOMNT,	SPECIE,		
	THERM									
COMBC	MAIN,	RESET,	SET2							
COMDBL	MAIN,	RESET,	SET,	SPECIE,	THERM,	WISUB				
COMEDG	ENERGY,	MAIN,	SET,	SHVALS,	SPECIE					
COMEL	BLDATA,	MAIN								
COMFAC	ENERGY,	MAIN,	SMOMNT,	SPECIE						
COMFS	MAIN,	RESET,	SHVALS,	THERM						
COMFSA	BLDATA,	ENERGY,	HCP,	HCPA,	MAIN,	RESET,	SET,	SET2,		
	SHVALS,	SPECIE,	THERM							
COMG	ENERGY,	MAIN,	MASS,	NMOMNT,	RESET,	SET,	SMOMNT,	SPECIE		
COMG1	ENERGY,	MAIN,	SMOMNT,	SPECIE						
COMG2	ENERGY,	MAIN,	MASS,	NMOMNT,	RESET,	SET,	SMOMNT,	SPECIE		
COMG3	MAIN,	MASS,	RESET							
COMNS	ENERGY,	HCP,	HCPA,	MAIN,	RESET,	SET,	SET2,	SHVALS,		
	SPECIE,	THERM,	VISCNA,	VISCON,	WISUB					
COMNS2	MAIN,	SET2,	SPECIE,	WISUB						
COMPRF	MAIN,	RESET								
COMREF	ENERGY,	MAIN,	RESET,	SHVALS,	THERM,	WISUB				
COMRX	MASS,	RESET								

COMSET	RTEDTA,	SET2						
COMSML	HCP,	HCPA,	INTRPS,	INTRP3,	MAIN,	RESET,	SMTHAR,	SPECIE
CONSUM	ENERGY,	RESET,	SPECIE					
COMSO	MAIN,	NMOMNT,	SET					
COMTAB	BLDATA,	HCP,	HCPA					
COMTST	ENERGY,	MAIN,	SMOMNT,	SPECIE				
COMUV	ENERGY,	MAIN,	SMOMNT					
COMVS	BLDATA,	MAIN,	RESET,	SHVALS,	THERM,	VISCNA,	VISCON,	WISUB
COMVSP	MAIN,	MASS						
COMW	ENERGY,	MAIN,	RESET,	SET,	SET2,	SPECIE,	THERM	
COMXR	MAIN,	RESET,	RTEDTA					
INSH	ENERGY,	MAIN,	MASS,	NMOMNT,	RESET,	SHVALS,	SMOMNT,	SPECIE
INV2	MAIN,	MASS,	RESET					
KJI	GEOM,	MAIN						
KNTR	MAIN,	RESET						
OUTSH	ENERGY, THERM	MAIN,	MASS,	NMOMNT,	RESET,	SHVALS,	SMOMNT,	SPECIE
PRLE	MAIN,	RESET,	SPECIE,	THERM				
RTECON	SET2,	WISUB						
SOLV	ENERGY, SOLVE,	MAIN, SPECIE,	MASS, THERM	NMOMNT,	RESET,	SET,	SHVALS,	SMOMNT,
TITLE	MAIN,	RESET						

Note: BLDATA stands for BLOCK DATA.

Listing of PROGRAM VISLNABB

The FORTRAN source statements of Program VISLNABB are listed on the following pages.

C	PROGRAM VISLNABB	MAIN	1
C		MAIN	2
C	MAIN CONTROLS LOGIC FLOW OF THE PROGRAM, PERFORMS SOME	MAIN	3
C	CALCULATIONS, AND UP DATES THE SHOCK SHAPES.	MAIN	4
C		MAIN	5
C	MAIN CALLS SUBROUTINES DERIV3, ENERGY, GEOM, INTRP3, MASS, NMOMNT,	MAIN	6
C	RESET, RTEDTA, SET, SET2, SHVALS, SMOMNT,	MAIN	7
C	SMTHPR, SPECIE, THERM, AND VPRFLE	MAIN	8
C		MAIN	9
C	* * JCL FOR IBM 370/158 * *	MAIN	10
C		MAIN	11
C	//JOB CARD	MAIN	12
C	// EXEC FORTGCLG, REGION=200K	MAIN	13
C	//FORT.SYSIN DD *	MAIN	14
C		MAIN	15
C	FORTRAN SOURCE PROGRAM	MAIN	16
C		MAIN	17
C	/*	MAIN	18
C	//GO.FT01F001 DD SYSOUT=A	MAIN	19
C	//GO.FT03F001 DD SYSOUT=A	MAIN	20
C	//GO.FT04F001 DD *	MAIN	21
C		MAIN	22
C	BODY GEOMETRY DATA	MAIN	23
C		MAIN	24
C	/*	MAIN	25
C	//GO.FT08F001 DD SYSOUT=A	MAIN	26
C	//GO.FT09F001 DD SYSOUT=A	MAIN	27
C	//GO.FT15F001 DD UNIT=SYSDA, DISP=(NEW,DELETE), SPACE=(440,(200)),	MAIN	28
C	// DCB=(RECFM=VS, BLKSIZE=440, LRECL=436)	MAIN	29
C	//GO.FT16F001 DD UNIT=SYSDA, DISP=(NEW,DELETE), SPACE=(440,(200)),	MAIN	30
C	// DCB=(RECFM=VS, BLKSIZE=440, LRECL=436)	MAIN	31
C	//GO.FT19F001 DD *	MAIN	32
C		MAIN	33
C	REACTION RATE DATA	MAIN	34
C		MAIN	35
C	/*	MAIN	36
C	//GO.FT20F001 DD *	MAIN	37
C		MAIN	38
C	SHOCK SHAPE DATA	MAIN	39
C		MAIN	40
C	/*	MAIN	41
C	//GO.SYSIN DD *	MAIN	42
C		MAIN	43
C	UNIT 5 - INPUT DATA	MAIN	44
C		MAIN	45
C	/*	MAIN	46
C	//	MAIN	47
C		MAIN	48
C		MAIN	49
C	CCOMON /BODY/ HANGLE,XJFAC,IGECM,JFAC	MAIN	50
C	CCOMON /COMARL/ XNSP(202),XSCL(200)	MAIN	51
C	CCOMON /COMAR1/ AA(51),BB(51),CAEQ(51),CON(51),CO1(51),CO2(51),CPSMAIN	MAIN	52
C	1T(51),EMBAR(51),PC(51),PCN(51),PE(51),PFAC(51),PS(51),PO(51),PON(51),MAIN	MAIN	53
C	21),P1(51),P1N(51),P2(51),P2N(51),Q1(51),Q2(51),RC(51),RCON(51),RCSMAIN	MAIN	54
C	3F(51),RNSH(51),RVISC(51),R1(51),R2(51),TC(51),T1(51),T2(51),T20(51),MAIN	MAIN	55
C	4),T21(51),UC(51),UCN(51),UC1(51),U1(51),U2(51),U20(51),VC(51),VCD(51),MAIN	MAIN	56
C	551),VC11(51),VC12(51),VG(51),VGN(51),VGS(51),VISC(51),VS(51),VO(51),MAIN	MAIN	57
C	6),VON(51),V1(51),V2(51),V2N(51)	MAIN	58
C	CCOMON /COMBC/ CAINF,CAW,CINF6(6),CIWW6(6)	MAIN	59
C	CCOMON /COMDBL/ AJB(51,6),AJM(51,6),CC(51,6),CCL(51,6),CCN(51,6),CMAIN	MAIN	60
C	1PI(51,6),C1(51,6),C2(51,6),C20(51,6),DW(51,6),HI(51,6),W0(51,6),W1MAIN	MAIN	61
C	2(51,6)	MAIN	62
C	CCOMON /COMEDG/ CIE(6),TCIE	MAIN	63
C	COMMON /COMEL/ ELN(6),ELO(6)	MAIN	64
C	CCOMON /COMFAC/ CCFAC,UFAC	MAIN	65
C	CCOMON /COMFS/ PINF,REYN,RINF,TINF,UINF	MAIN	66
C	COMMON /COMFSA/ CINF(6),CPIFS(6),DELHIF(6),HINF(6)	MAIN	67
C	CCOMON /COMG/ CAT,CNS,CRNI,REFAC,SSFAC,SWFAC,THIN,VPG,I,K,NITER	MAIN	68
C	CCOMON /COMG1/ CP,CPB,SP,SPB	MAIN	69
C	CCOMON /COMG2/ CK,CK2,CSF2,RS2,SIF2,XB2,XNSPM	MAIN	70
C	COMMON /COMG3/ CSF,RS,SIF,XB,XNS1	MAIN	71

COMMON /COMNS/ NS	MAIN	72
COMMON /COMNS2/ NJ,NR,NSM1,NZ	MAIN	73
COMMON /COMPRF/ SPRF(10),NSPRF	MAIN	74
COMMON /COMREF/ CONREF,CPREF,HREF,PREF,RREF,TREF,UREF,VSREF,WREF	MAIN	75
COMMON /COMSHL/ SMALLT	MAIN	76
COMMON /COMSO/ PPS0,TTSO,VVSO,UUS0,NSOLD	MAIN	77
COMMON /COMTST/ DIFI(8),DIF,XU25	MAIN	78
COMMON /COMUV/ URSH,VRSH	MAIN	79
COMMON /COMVS/ EMI(6),VSA(6),VSB(6),VSC(6),R,NSPI(6)	MAIN	80
COMMON /COMVSP/ VSPP1,VSPP2	MAIN	81
COMMON /COMW/ CIW(6),CIWW(6),CPIW(6),HIW(6),HTFLB,TB,TCNW,TW	MAIN	82
COMMON /COMXR/ ALP,ALT,BRAD,B0,CDF,CDFD,CDF1,CDF2,CDP,CDPD,CDP1,CDMAIN	83	
1P2,OLDSL,PHI,SEND,WVFAC,XNS0,IEND,IUN,KPLTTP,NITMIN,NITTOT,NTOT,NHMAIN	84	
2TPL,NTW	MAIN	85
COMMON /INSH/ CONO,S,UPSH,XNS,EPS,TPSH,VISCO	MAIN	86
COMMON /INV2/ XNSA,XNSIVO,XNSIV1,XNSTMP,NAN	MAIN	87
COMMON /KJI/ IJK	MAIN	88
COMMON /KNTR/ KNTR1,KNTW1,KNTW2	MAIN	89
COMMON /OUTSH/ PPS,PPS1,PPS2,PSP,REYSH,RRS,RRS1,RRS2,RSP,TSP,TTS,TMAIN	90	
1TS1,TTS2,USP,UUS,UUS1,UUS2,VSP,VVS,VVS1,VVS2	MAIN	91
COMMON /PRLE/ SIGM,XLE	MAIN	92
COMMON /SOLV/ A1(51),A2(51),A3(51),A4(51),ON(52),DS,XN(52),IE,IM	MAIN	93
COMMON /TITLE/ KTITLE(20)	MAIN	94
	MAIN	95
DIMENSION ENSHN(301), SHSLPN(301), SN(301), XXNP(301)	MAIN	96
DIMENSION STWA(100), TWA(100)	MAIN	97
DIMENSION CNVRGI(8), TERMN(6),	MAIN	98
	MAIN	99
C		
NAMelist /INPUT/ ALT,BRAD,CAINF,CAT,CAW,CCFAC,CONVRG,DS,DSMAX,HANGMAIN	100	
1LE,PRNTCI,RINF,SEND,SIGM,SITEST,SMALLT,SSFAC,SWFAC,TB,THINI,TINF,UMAIN	101	
2FAC,UINF,WVFAC,XKETA,XLE,XNS0,IE,IEND,IGEOM,IUN,JFAC,KEND,KPLTTP,KHMAIN	102	
3TWAL,NAN,NDATA,NITMAX,NITMIN,NITMNI,NS,NSI,NSPRF,NTSH,NTTWA	MAIN	103
	MAIN	104
C		
DATA BLNK/1H /	MAIN	105
	MAIN	106
C		
DATA XXNP/301*0.0/	MAIN	107
	MAIN	108
C		
IJK=0	MAIN	109
VPG=0.0	MAIN	110
READ (5,620) KTITLE	MAIN	111
WRITE (6,630) KTITLE	MAIN	112
KNTR1=0	MAIN	113
KNTW1=0	MAIN	114
KNTW2=0	MAIN	115
NTPL=13	MAIN	116
NTR=15	MAIN	117
NTW=16	MAIN	118
NTOT=0	MAIN	119
NSOLD=0	MAIN	120
	MAIN	121
C		
C		
INITIALIZE NAMelist INTEGER VARIABLES	MAIN	122
	MAIN	123
C		
IE=51	MAIN	124
IEND=200	MAIN	125
IUN=19	MAIN	126
JFAC=1	MAIN	127
KEND=2	MAIN	128
KPLTTP=0	MAIN	129
KTWAL=0	MAIN	130
NAN=1	MAIN	131
NCATA=0	MAIN	132
NITMAX=9999	MAIN	133
NITMIN=3	MAIN	134
NITMNI=3	MAIN	135
NS=2	MAIN	136
NSI=2	MAIN	137
NSPRF=0	MAIN	138
NTSH=5	MAIN	139
NTTWA=5	MAIN	140
	MAIN	141
C		
	MAIN	142

C	INITIALIZE NAMELIST REAL VARIABLES	MAIN 143
C	CAINF=0.0	MAIN 144
	CAT=1.0	MAIN 145
	CAW=0.0	MAIN 146
	CCFAC=0.0	MAIN 147
	CCNVRG=0.01	MAIN 148
	DS=0.1	MAIN 149
	DSMAX=5.0	MAIN 150
	HANGLE=10.0	MAIN 151
	PRNTCI=0.0	MAIN 152
	SEND=0.0	MAIN 153
	SIGM=0.7	MAIN 154
	SITEST=0.0001	MAIN 155
	SMALLT=1.0E-6	MAIN 156
	SSFAC=-1.0	MAIN 157
	SWFAC=-1.0	MAIN 158
	THINI=+1.00	MAIN 159
	UFAC=0.5	MAIN 160
	WVFAC=0.250	MAIN 161
	XKETA=1.0	MAIN 162
	XLE=1.4	MAIN 163
	XNSO=0.1166	MAIN 164
	DO 10 J=1,6	MAIN 165
	CINF(J)=0.00	MAIN 166
	CIWW(J)=0.00	MAIN 167
10	CCONTINUE	MAIN 168
	THIN=1.00	MAIN 169
C		MAIN 170
C	NAMELIST INPUT	MAIN 171
C		MAIN 172
	READ (5,INPUT)	MAIN 173
	IF (NDATA.EQ.0) SEND=DS*(IEND+1)	MAIN 174
	XJFAC=JFAC	MAIN 175
	WRITE (6,INPUT)	MAIN 176
	NSM1=NS-1	MAIN 177
	NSPL2=NS+2	MAIN 178
	DO 20 N=1,IE	MAIN 179
	VG(N)=0.0	MAIN 180
20	VGS(N)=0.0	MAIN 181
	READ (5,750) (CINF6(J),J=1,6)	MAIN 182
	READ (5,750) (CIWW6(J),J=1,6)	MAIN 183
	IF (NDATA.EQ.0) GO TO 80	MAIN 184
	N=0	MAIN 185
	N=N+1	MAIN 186
30		MAIN 187
C		MAIN 188
C	SHCCK SHAPE DATA	MAIN 189
C		MAIN 190
	READ (NTSH,700) SN(N),SHSLPN(N),ENSHN(N),ENO	MAIN 191
	IF (ENO.EQ.BLNK) GO TO 30	MAIN 192
	NSDATA=N	MAIN 193
	IF (SEND.LT.0.0001) SEND=SN(NSDATA)	MAIN 194
	IF (SEND.GT.SN(NSDATA)) SEND=SN(NSDATA)	MAIN 195
	CALL DERIV3 (ENSHN,SN,NSDATA,2,SHSLPN)	MAIN 196
	SHSLPN(1)=0.0	MAIN 197
	SHSLPN(NSDATA+1)=SHSLPN(NSDATA)	MAIN 198
	SN(NSDATA+1)=SN(NSDATA)+(SN(NSDATA)-SN(NSDATA-1))	MAIN 199
	DO 60 KLSQ=1,4	MAIN 200
	DO 40 N=2,NSDATA	MAIN 201
40	XXNP(N)=2.0*(SHSLPN(N+1)-SHSLPN(N-1))*(SN(N)-SN(N-1))/(3.0*(SN(N+1)-SN(N-1)))+(2.0*SHSLPN(N-1)+SHSLPN(N))/3.0	MAIN 202
	DO 50 N=2,NSDATA	MAIN 203
50	SHSLPN(N)=XXNP(N)	MAIN 204
60	CONTINUE	MAIN 205
	DO 70 N=1,300	MAIN 206
70	XXNP(N)=0.0	MAIN 207
	GO TO 100	MAIN 208
80	CONTINUE	MAIN 209
	IEND2=IEND+2	MAIN 210
	DO 90 N=1,IEND2	MAIN 211
90	XNSP(N)=0.00	MAIN 212
		MAIN 213

100	CCONTINUE	MAIN 214
	IF (KTWAL.EQ.0) GO TO 120	MAIN 215
	N=0	MAIN 216
110	N=N+1	MAIN 217
C		MAIN 218
C	WALL TEMPERATURE DATA	MAIN 219
C		MAIN 220
	READ (NTTWA,540) STWA(N),TWA(N),END	MAIN 221
	IF (ENO.EQ.BLNK) GO TO 110	MAIN 222
	NPTT=N	MAIN 223
120	CCONTINUE	MAIN 224
	IF (NSPRF.NE.0) READ (5,550) SPRF	MAIN 225
	IF (NSPRF.NE.0) SPRF(NSPRF)=SEND	MAIN 226
	CALL RTEDTA	MAIN 227
	IM=IE-1	MAIN 228
	DY=1.0/IM	MAIN 229
C		MAIN 230
C	SET GRID SPACING	MAIN 231
C		MAIN 232
	IF (XKETA.NE.1.0) DN(1)=(XKETA-1.0)/(XKETA**IM-1.0)	MAIN 233
	IF (XKETA.EQ.1.0) DN(1)=DY	MAIN 234
	XN(1)=0.0	MAIN 235
	DO 130 N=1,IE	MAIN 236
	DN(N+1)=XKETA*DN(N)	MAIN 237
130	XN(N+1)=XN(N)+DN(N)	MAIN 238
	XN(IE)=1.00	MAIN 239
	DSCLD=DS	MAIN 240
	IF (KPLTTP.NE.0) WRITE (NTPL,690) KTITLE	MAIN 241
C		MAIN 242
C	BEGIN MAIN LOCP	MAIN 243
C		MAIN 244
	DO 530 K=1,KEND	MAIN 245
	WRITE (1,730)	MAIN 246
	WRITE (3,740)	MAIN 247
	IF (NDATA.EQ.0) GO TO 150	MAIN 248
C		MAIN 249
C	PRINT SHOCK SHAPE DATA	MAIN 250
C		MAIN 251
	WRITE (8,640) K	MAIN 252
	WRITE (8,710)	MAIN 253
	DO 140 N=1,NSDATA	MAIN 254
	WRITE (8,720) SN(N),SHSLPN(N),N	MAIN 255
140	CONTINUE	MAIN 256
150	CCONTINUE	MAIN 257
	WRITE (8,640) K	MAIN 258
	WRITE (8,650)	MAIN 259
	DO 160 J=1,NSPL2	MAIN 260
160	CNVRGI(J)=CONVRG	MAIN 261
	IF (NS.EQ.6) CNVRGI(7)=CONVRG*100.0	MAIN 262
	IF (NS.EQ.2.AND.CAT.LE.0.0) CNVRGI(4)=CONVRG*100.0	MAIN 263
	NITER=0	MAIN 264
	UPSH=0.00	MAIN 265
	TPSH=0.00	MAIN 266
	VISCO=0.00	MAIN 267
	CONO=0.00	MAIN 268
	XNS=XNSO	MAIN 269
	XNS1=XNS	MAIN 270
	DS1=DS	MAIN 271
	DS2=DS/2.00	MAIN 272
	CK=1.00	MAIN 273
	CSF=0.00	MAIN 274
	SIF=1.00	MAIN 275
	RS=0.00	MAIN 276
	RS2=0.00	MAIN 277
	XB=0.0	MAIN 278
	CDF=0.0	MAIN 279
	CDP=0.0	MAIN 280
	CDP1=0.	MAIN 281
	CDP2=0.	MAIN 282
	CDF1=0.	MAIN 283
	CDF2=0.	MAIN 284

	CDPD=0.	MAIN 285
	CDFO=0.	MAIN 286
	CNS=(XNS1+XNS)/2.	MAIN 287
	CRNI=1.0	MAIN 288
	NITTOT=0	MAIN 289
	S=-DS2	MAIN 290
	S1=S+DS2	MAIN 291
	IF (THIN.LE.0.0) CALL VPRFLE (S1,VSP1,VO,IE,NTR,1)	MAIN 292
	UUS0=0.0	MAIN 293
	PPS0=0.833	MAIN 294
	VVS0=-0.167	MAIN 295
	TTS0=0.486	MAIN 296
	RRS0=6.0	MAIN 297
	URSH=0.0	MAIN 298
	VRSH=VVS0	MAIN 299
	TTSH=TTS0	MAIN 300
	TTS2=TTS0	MAIN 301
	PPS=PPS0	MAIN 302
	RRS=RRS0	MAIN 303
	TTS=TTS0	MAIN 304
	CALL SET2	MAIN 305
	CALL THERM (1,BRAD,CONC,VISCO,EPS,VIS2)	MAIN 306
	CALL SET	MAIN 307
	AA(1)=0.0	MAIN 308
	BB(1)=0.0	MAIN 309
	XNSP(1)=0.0	MAIN 310
C		MAIN 311
C	BEGIN SOLUTION ALONG BODY	MAIN 312
C		MAIN 313
	DO 390 I=1,IEND	MAIN 314
170	S=S+DS2	MAIN 315
	IF (KTWAL.EQ.0) GO TO 180	MAIN 316
	NUTW=2	MAIN 317
	CALL SMTHPR (S,TW,STWA,TWA,NPTT,NUTW)	MAIN 318
	TW=TW/TREF	MAIN 319
180	CONTINUE	MAIN 320
	IF (THIN.GE.0.0) GO TO 190	MAIN 321
C		MAIN 322
C	RETRIEVE V PROFILES FOR FVSL	MAIN 323
C		MAIN 324
	S1=S	MAIN 325
	S2=S+DS	MAIN 326
	CALL VPRFLE (S1,VSP1,VC11,IE,NTR,2)	MAIN 327
	CALL VPRFLE (S2,VSP2,VC12,IE,NTR,2)	MAIN 328
C		MAIN 329
190	CONTINUE	MAIN 330
	CALL GEOM (S,DS2,RS2,CK2,CSF2,SIF2,XB2)	MAIN 331
	PHI=ARCOS(CSF2)	MAIN 332
C		MAIN 333
C	NCDATA = 1 / USE TABULATED SHOCK SLOPE DATA	MAIN 334
C		MAIN 335
	IF (NCDATA.EQ.0) GO TO 200	MAIN 336
	SPDS=S+DS	MAIN 337
	CALL INTRP3 (SPDS,SN,SHSLPN,NCDATA,XNSP(I+1))	MAIN 338
200	CONTINUE	MAIN 339
	XNSPM=(XNSP(I)+XNSP(I+1))/2.00	MAIN 340
	ALP=PHI+ATAN(XNSPM/(1.0+CK2*XNS))	MAIN 341
	GLDCLP=XNSP(I)	MAIN 342
	WRITE (8,680) I,S,GLDCLP,XNSPM,ALP	MAIN 343
	SP=SIN(ALP)	MAIN 344
	CP=COS(ALP)	MAIN 345
	SPB=SP*SIF2+CP*CSF2	MAIN 346
	CPB=CP*SIF2-SP*CSF2	MAIN 347
210	CONTINUE	MAIN 348
	DIF=0.0	MAIN 349
	DO 220 J=1,NSPL2	MAIN 350
220	DIFI(J)=0.00	MAIN 351
	TGUE=0.0	MAIN 352
230	CONTINUE	MAIN 353
	TCIE=TC(IE)*TTS*TREF	MAIN 354
	CALL SHVALS (SP,CP,SPB,CPB,TTSH,VRSH,URSH,PPSH,2)	MAIN 355

	IF (S.GE.0.0001) GO TO 240	MAIN 356
	CALL SHVALS (1.00,0.00,1.00,0.00,TTS0,VVS0,UUS0,PPS0,1)	MAIN 357
	B0=TW/TTS0	MAIN 358
240	CONTINUE	MAIN 359
	SIT=ABS(TGUE-TTS)	MAIN 360
	TGUE=TTS	MAIN 361
C		MAIN 362
C	ITERATE FOR SHOCK TEMPERATURE	MAIN 363
C		MAIN 364
	IF (SIT.GE.SITEST) GO TO 230	MAIN 365
	CALL THERM (2,BRAD,CONO,VISCO,EPS,VIS2)	MAIN 366
	REFAC=RRS*VVS*CNS/(EPS*EPS*VISCO)	MAIN 367
	XKSL=VIS2*RRS*VVS*SQR(PPS2*P2(1)/(RRS2*R2(1)))/(PPS2*P2(1)*REFAC)	MAIN 368
	DO 260 N=1,IE	MAIN 369
	IF (S.GE.0.0001) GO TO 250	MAIN 370
	PFAC(N)=4.00*(P2(N)+(PPS2/PPS0-2.00)*P0(N))/(UUS2*DS)-XNSP(2)*XN(N)	MAIN 371
	1)*PON(N)/(2.00*UUS2*CNS)	MAIN 372
	GO TO 260	MAIN 373
250	VC(N)=VCD(N)/VVS	MAIN 374
260	CONTINUE	MAIN 375
C		MAIN 376
C	SOLVE GOVERNING EQUATIONS	MAIN 377
C		MAIN 378
	CALL SPECIE	MAIN 379
	CALL ENERGY	MAIN 380
	CALL SMOMNT	MAIN 381
	CALL MASS	MAIN 382
	CALL NMOMNT	MAIN 383
	NITER=NITER+1	MAIN 384
	NITTOT=NITTOT+1	MAIN 385
	NTCT=NTOT+1	MAIN 386
	TFACT=XU25-U2(15)	MAIN 387
	DIFI(1)=DIF	MAIN 388
	IF (PRNTCI.LT.0.5) GO TO 300	MAIN 389
C		MAIN 390
C	PRINT SPECIES PROFILES AND ATOM SUMS	MAIN 391
C		MAIN 392
	WRITE (6,560) K,I,S,NITER,DIF	MAIN 393
	IF (NS.EQ.6) WRITE (6,570) (NSPI(J),J=1,NS)	MAIN 394
	IF (NS.EQ.2) WRITE (6,580) (NSPI(J),J=1,NS)	MAIN 395
	WRITE (6,590) (DIFI(J),J=1,NSPL2)	MAIN 396
	DO 270 J=1,NS	MAIN 397
	TERMN(J)=ELN(J)*EMI(4)/EMI(J)	MAIN 398
	TERMO(J)=ELO(J)*EMI(1)/EMI(J)	MAIN 399
270	CCATINUE	MAIN 400
	DO 290 N=1,IE	MAIN 401
	SUM=0.0	MAIN 402
	SUMN=0.00	MAIN 403
	SUMO=0.00	MAIN 404
	DO 280 J=1,NS	MAIN 405
	SUMN=SUMN+CC(N,J)*TERMN(J)	MAIN 406
	SUMO=SUMO+CC(N,J)*TERMO(J)	MAIN 407
280	SUM=SUM+CC(N,J)	MAIN 408
	SUM=SUM-1.00	MAIN 409
	WRITE (6,600) N,XN(N),UC(N),TC(N),(CC(N,J),J=1,NS),SUM,SUMO,SUMN	MAIN 410
290	CONTINUE	MAIN 411
300	CONTINUE	MAIN 412
C		MAIN 413
C	PRINT PROFILE DIFFERENCES	MAIN 414
C		MAIN 415
	IF (PRNTCI.LT.0.5) WRITE (6,610) K,I,S,NITER,(DIFI(J),J=1,NSPL2)	MAIN 416
	WRITE (9,660) K,I,S,NITER,NITTOT,TFACT,DIF,XNS,CNS	MAIN 417
	IF (NITER.LT.NITMAX) GO TO 330	MAIN 418
	DO 310 J=1,NSPL2	MAIN 419
C		MAIN 420
C	TEST FOR CONVERGENCE	MAIN 421
C		MAIN 422
	IF (DIFI(J).GT.CNVRGI(J)) GO TO 320	MAIN 423
310	CGNTINUE	MAIN 424
	GC TO 350	MAIN 425
320	CONTINUE	MAIN 426

	IF (I.EQ.1) GO TO 330	MAIN 427
	WRITE (6,670) S,TFACT,NITER,NITTOT,DIF,CONVRG	MAIN 428
C		MAIN 429
C	CUT STEP SIZE IN HALF AND TRY FOR SOLUTION AGAIN	MAIN 430
C	IF NITER .EQ. NITMAX	MAIN 431
C		MAIN 432
	DS=DS/2.0	MAIN 433
	DS2=DS/2.0	MAIN 434
	S=S-DS-DS2	MAIN 435
	CALL GEOM (S,DS2,RS,CK,CSF,SIF,XB)	MAIN 436
	NITER=0	MAIN 437
	GO TO 170	MAIN 438
330	CCONTINUE	MAIN 439
	DO 340 J=1,NSPL2	MAIN 440
	IF (DIFI(J).GT.CNVRGI(J)) GO TO 210	MAIN 441
340	CCONTINUE	MAIN 442
350	CCONTINUE	MAIN 443
C		MAIN 444
C	PRINT SOLUTION DATA AND RESET VARIABLE FOR NEXT GLOBAL ITERATION	MAIN 445
C		MAIN 446
	CALL RESET	MAIN 447
	DS=DS1	MAIN 448
	IF (NITER.GT.NITMIN) GO TO 360	MAIN 449
	IF (DS.GE.DSMAX) GO TO 360	MAIN 450
C		MAIN 451
C	DOUBLE STEP SIZE	MAIN 452
C		MAIN 453
	DS=DS*2.0	MAIN 454
360	CONTINUE	MAIN 455
	RS=RS2	MAIN 456
	DS1=DS	MAIN 457
	IEI=1	MAIN 458
	IF (NSPRF.EQ.0) GO TO 380	MAIN 459
	DO 370 NK=1,NSPRF	MAIN 460
	IF (S.GE.SPRF(NK)) GO TO 370	MAIN 461
	IF (ABS(1.00-S/SPRF(NK)).LE.SMALLT) GO TO 370	MAIN 462
	IF ((S+1.25*DS).LE.SPRF(NK)) GO TO 370	MAIN 463
	DS=SPRF(NK)-S	MAIN 464
	GO TO 380	MAIN 465
370	CCONTINUE	MAIN 466
380	CCONTINUE	MAIN 467
	IF (ABS(1.00-S/SEND).LE.SMALLT) GO TO 400	MAIN 468
	IF (S.GE.SEND) GO TO 400	MAIN 469
	DS2=DS/2.00	MAIN 470
	S=S+DS2	MAIN 471
	CALL GEOM (S,DS2,RS,CK,CSF,SIF,XB)	MAIN 472
	RS2=RS	MAIN 473
	NITER=0	MAIN 474
390	CONTINUE	MAIN 475
C		MAIN 476
C	END SOLUTION ALONG BODY	MAIN 477
C		MAIN 478
400	CCONTINUE	MAIN 479
	S1=S+DS1	MAIN 480
	S2=S1+DS1	MAIN 481
	WRITE (NTW) S1,VVS,VSP,VC12	MAIN 482
	WRITE (NTW) S2,VVS,VSP,VC12	MAIN 483
	S1=S2+DS1	MAIN 484
	S2=S1+DS1	MAIN 485
	WRITE (NTW) S1,VVS,VSP,VC12	MAIN 486
	WRITE (NTW) S2,VVS,VSP,VC12	MAIN 487
	KNTW1=KNTW1+4	MAIN 488
	IF (NDATA.EQ.0) GO TO 480	MAIN 489
C		MAIN 490
C	UPDATE SHOCK SHAPE DATA	MAIN 491
C		MAIN 492
	IEI1=IEI+1	MAIN 493
	XSGL(IEI1)=XSGL(IEI)+DS	MAIN 494
	XNSP(IEI1)=XNSP(IEI)	MAIN 495
	DO 430 KLSQ=1,4	MAIN 496
	DO 410 N=2,IEI	MAIN 497

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410  XXNP(N)=2.0*(XNSP(N+1)-XNSP(N-1))*(XSOL(N)-XSOL(N-1))/(3.0*(XSOL(NMAIN 498
1+1)-XSOL(N-1)))+(2.0*XNSP(N-1)+XNSP(N))/3.0 MAIN 499
DO 420 N=2,IEI MAIN 500
420  XNSP(N)=XXNP(N) MAIN 501
430  CONTINUE MAIN 502
DO 440 N=2,NSDATA MAIN 503
NN=NN MAIN 504
IF (SN(NN).GE.XSOL(IEI)) GO TO 450 MAIN 505
440  CCNTINUE MAIN 506
GO TO 460 MAIN 507
450  NSDATA=NN MAIN 508
460  CCNTINUE MAIN 509
DO 470 N=2,NSDATA MAIN 510
470  CALL INTRP3 (SN(N),XSOL,XNSP,IEI,SHSLPN(N)) MAIN 511
GO TO 520 MAIN 512
480  CONTINUE MAIN 513
C MAIN 514
C AVERAGE SHOCK SHAPE FOR ANALYTIC BODIES MAIN 515
C MAIN 516
XNSP(IEND+1)=XNSP(IEND) MAIN 517
DO 510 KLSQ=1,4 MAIN 518
DO 490 N=2,IEND MAIN 519
490  XXNP(N)=(XNSP(N-1)+XNSP(N)+XNSP(N+1))/3. MAIN 520
DO 500 N=2,IEND MAIN 521
500  XNSP(N)=XXNP(N) MAIN 522
510  CCNTINUE MAIN 523
520  CCNTINUE MAIN 524
C MAIN 525
C SET COUNTERS FOR NEXT GLOBAL ITERATION MAIN 526
C MAIN 527
REWIND NTR MAIN 528
REWIND NTW MAIN 529
NTO=NTR MAIN 530
NTR=NTW MAIN 531
NTW=NTO MAIN 532
KNTW2=KNTW1 MAIN 533
KNTR1=0 MAIN 534
KNTW1=0 MAIN 535
DS=DSOLD MAIN 536
THIN=THINI MAIN 537
NITMIN=NITMNI MAIN 538
NSCLD=NS MAIN 539
NS=NSI MAIN 540
NSM1=NS-1 MAIN 541
NSPL2=NS+2 MAIN 542
530  CONTINUE MAIN 543
C MAIN 544
C END MAIN LOOP MAIN 545
C MAIN 546
C RETURN MAIN 547
C MAIN 548
C MAIN 549
C MAIN 550
540  FORMAT (2E15.6,A1) MAIN 551
550  FORMAT (10F8.0) MAIN 552
560  FORMAT (1H1,2X,3HK =,I1,4H,I =,I3,4H,S =,F10.6,9H, NITER =,I3,7H, MAIN 553
1DIF =,E15.7) MAIN 554
570  FORMAT (1H0,4X,1HN,3X,2HXN,7X,2HUC,7X,2HTC,2X,6(7X,A4),2X,9HSUMCI-MAIN 555
11.0,7X,4HSUM0,7X,4HSUMN) MAIN 556
580  FORMAT (1H0,4X,1HN,3X,2HXN,7X,2HUC,7X,2HTC,2X,2(7X,A4),2X,9HSUMCI-MAIN 557
11.0,7X,4HSUM0,7X,4HSUMN) MAIN 558
590  FORMAT (1H ,7X,6H(DIFI),1X,2F9.6,1PE11.4,5E11.4) MAIN 559
600  FORMAT (1H ,2X,I3,3F9.6,1PE11.4,8E11.4) MAIN 560
610  FORMAT (1H ,3HK =,I1,5H, I =,I3,5H, S =,F7.3,9H, NITER =,I3,8H, DIMAIN 561
1FI =,1PE10.3,7E10.3) MAIN 562
620  FORMAT (20A4) MAIN 563
630  FORMAT (1H0,///25X,20A4,///) MAIN 564
640  FORMAT (1H1,20X,3HK =,I2) MAIN 565
650  FORMAT (1H0,8HSTA. NO.,10X,1HS,7X,8HOLD XNSP,10X,5HXNSPM,2X,13HALPMAIN 566
1HATS+DS/2),7X,8HNEW XNSP,6X,2X,7HNEW YSH,12X,3HXSH,12X,3HRSH) MAIN 567
660  FORMAT (1H ,2HK=,I2,4H, I=,I3,3H,S=,F10.6,9H, NITER =,I5,10H, NITTMMAIN 568

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10T =,15,9H, TFACT =,E15.7,7H, DIF =,E15.7,1P2E14.6) MAIN 569
670 FORMAT (1H0,2X,3HS =,F10.6,9H, TFACT =,1PE15.7,9H, NITER =,I5,11H,MAIN 570
1 NITTOT =,I5,7H, DIF =,E16.7,10H, CONVRG =,E15.7) MAIN 571
680 FORMAT (1H ,1X,I3,4F15.10) MAIN 572
690 FORMAT (20A4) MAIN 573
700 FORMAT (3E15.6,A1) MAIN 574
710 FORMAT (1H0,8X,1HS,13X,4HYSH,8X,1HN) MAIN 575
720 FORMAT (1H ,2E15.6,I5) MAIN 576
730 FCRMAT (2H- ,1HK,4X,1HI,6X,4HS/RN,3X,4HITER,6X,3HYSH,9X,4HYSH,8X,MAIN 577
12HCF,10X,4HHEAT,8X,4HSTAN,8X,5HPW/PO,7X,4HQ/QO,8X,1HS,11X,4HQDOT//MAIN 578
2) MAIN 579
740 FORMAT (1H0,//2X,1HK,4X,1HI,1X,4HITER,6X,4HS/RN,8X,3HYSH,9X,5HYSH-MAIN 580
1D,7X,6HYSH-ST,6X,6HYSH-AV,3X,9HE-/CC,MAX,4X,8HXN,E-MAX,4X,8HY,IN,EMAIN 581
2-M,6X,4HS/RN,8X,4HS FT//) MAIN 582
750 FORMAT (6F10.5) MAIN 583
END MAIN 584

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SUBROUTINE DERIV3 (F,X,IMAX,IMIN,FP) DERV 1
C DERV 2
C SUBROUTINE DERIV3 CALCULATES THE FIRST DERIVATIVES OF F WITH DERV 3
C RESPECT TO X AND RETURNS THE ARRAY FP DERV 4
C DERV 5
C SUBROUTINE DERIV3 IS CALLED BY MAIN AND SUBROUTINES ENERGY, MASS, DERV 6
C SET, SMOMNT, SOLVE, SPECIE, AND THERM. DERV 7
C DERV 8
C DIMENSION F(IMAX), X(IMAX), FP(IMAX) DERV 9
C DERV 10
C DERV 11
DO 10 J=IMIN,IMAX DERV 12
K=J DERV 13
IF (K.LT.(IMIN+1)) K=IMIN+1 DERV 14
IF (K.GT.(IMAX-1)) K=IMAX-1 DERV 15
AN1=2.0*X(J)-X(K)-X(K+1) DERV 16
AN2=2.0*X(J)-X(K-1)-X(K+1) DERV 17
AN3=2.0*X(J)-X(K-1)-X(K) DERV 18
DN1=(X(K-1)-X(K))*(X(K-1)-X(K+1)) DERV 19
DN2=(X(K)-X(K-1))*(X(K)-X(K+1)) DERV 20
DN3=(X(K+1)-X(K-1))*(X(K+1)-X(K)) DERV 21
CN1=AN1/DN1 DERV 22
CN2=AN2/DN2 DERV 23
CN3=AN3/DN3 DERV 24
FP(J)=CN1*F(K-1)+CN2*F(K)+CN3*F(K+1) DERV 25
10 CONTINUE DERV 26
RETURN DERV 27
END DERV 28

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SUBROUTINE ENERGY ENRG 1
C ENRG 2
C SUBROUTINE ENERGY SOLVES THE ENERGY EQUATION ENRG 3
C ENRG 4
C SUBROUTINE ENERGY CALLS SUBROUTINES DERIV3, HCP, AND SOLVE. ENRG 5
C ENRG 6
C SUBROUTINE ENERGY IS CALLED BY MAIN. ENRG 7
C ENRG 8
C COMMON /BODY/ HANGLE,XJFAC,IGECM,JFAC ENRG 9
COMMON /COMARL/ XNSP(202),XSGL(200) ENRG 10
COMMON /COMAR1/ AA(51),BB(51),CAEQ(51),CON(51),CO1(51),CO2(51),CPSENRG 11
1T(51),EMBAR(51),PC(51),PCN(51),PE(51),PFAC(51),PS(51),PO(51),PON(5ENRG 12
21),P1(51),PIN(51),P2(51),P2N(51),Q1(51),Q2(51),RC(51),RCON(51),RCSENRG 13
3F(51),RNSH(51),RVISC(51),R1(51),R2(51),TC(51),T1(51),T2(51),T20(51ENRG 14
4),T21(51),UC(51),UCN(51),UC1(51),U1(51),U2(51),U20(51),VC(51),VCD(ENRG 15
551),VC11(51),VC12(51),VG(51),VGN(51),VGS(51),VISC(51),VS(51),VO(51ENRG 16
6),VON(51),V1(51),V2(51),V2N(51) ENRG 17

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COMMON /COMEDG/ CIE(6),TCIE                                ENRG 18
COMMON /COMFAC/ CCFAC,UFAC                                ENRG 19
COMMON /COMFSA/ CINF(6),CPIFS(6),DELHIF(6),HINF(6)        ENRG 20
COMMON /COMG/ CAT,CNS,CRNI,REFAC,SSFAC,SWFAC,THIN,VPG,I,K,NITER ENRG 21
COMMON /COMG1/ CP,CPB,SP,SPB                               ENRG 22
COMMON /COMG2/ CK,CK2,CSF2,RS2,SIF2,XB2,XNSPM             ENRG 23
COMMON /COMNS/ NS                                           ENRG 24
COMMON /COMREF/ CONREF,CPREF,HREF,PREF,RREF,TREF,UREF,VSREF,WREF ENRG 25
COMMON /COMSUM/ CPJSUM(51),HDWSUM(51),HWSUM(51),HJSUMW    ENRG 26
COMMON /COMTST/ DIFI(8),DIF,XU25                           ENRG 27
COMMON /COMUV/ URSH,VRSH                                    ENRG 28
COMMON /COMW/ CIW(6),CIWW(6),CPIW(6),HIW(6),HTFLB,TB,TCNW,TW ENRG 29
COMMON /INSH/ CONO,S,UPSH,XNS,EPS,TPSH,VISCO             ENRG 30
COMMON /OUTSH/ PPS,PPS1,PPS2,PSP,REYSH,RRS,RRS1,RRS2,RSP,TSP,TTS,TENRG 31
1TTS1,TTS2,USP,UUS,UUS1,UUS2,VSP,VVS,VVS1,VVS2          ENRG 32
COMMON /SOLV/ A1(51),A2(51),A3(51),A4(51),DN(52),DS,XN(52),IE,IM ENRG 33
C
DIMENSION HII(6), HFAC(6), CPII(6)                        ENRG 34
C
DC 10 N=1,IE                                               ENRG 35
CHM1=CPJSUM(N)*CNS/(CON(N)*CGNO)                          ENRG 36
CHMFAC=CNS*CNS*RRS*RC(N)/(EPS*EPS*CONO*CON(N))            ENRG 37
CHM2=CHMFAC*HWSUM(N)/TTS                                  ENRG 38
CHM3=CHMFAC*HDWSUM(N)                                     ENRG 39
CHM4=CHM3*TC(N)                                           ENRG 40
C
CALCULATE COEFFICIENTS FOR PARTIAL DIFFERENTIAL EQUATION ENRG 41
C
A1(N)=REFAC*VISCO*CPST(N)*((UUS*XNSP(I)*RNSH(N)*RC(N)*UC(N)*XN(N))/(ENRG 42
1VVS*CNS)-RC(N)*VC(N))/(CONO*CON(N))+RCON(N)+CK*RNSH(N)+RCSF(N)*XJFENRG 43
2AC-CHM1                                                    ENRG 44
A4(N)=-REFAC*VISCO*CPST(N)*UUS*RNSH(N)*RC(N)*UC(N)/(VVS*CONO*CON(NENRG 45
1))                                                         ENRG 46
A2(N)=A4(N)*TSP/TTS-CHM3                                    ENRG 47
A3(N)=REFAC*PPS*VISCO*(RNSH(N)*UUS*UUS*UC(N)*PFAC(N)+VVS*VC(N)*PCNENRG 48
1(N))/(TTS*RRS*VVS*CONO*CON(N))+UUS*UUS*VISC(N)*VISCO*(UCN(N)-CK*RNENRG 49
2SH(N)*UC(N))*2/(TTS*CONO*CON(N))-CHM2+CHM4              ENRG 50
TTS2TR=TTS2*TREF                                           ENRG 51
CALL HCP (TTS2TR,CPII,HII,HFAC)                            ENRG 52
SUMCDH=0.0                                                  ENRG 53
SUMCHF=0.0                                                  ENRG 54
DO 20 J=1,NS                                               ENRG 55
SUMCDH=SUMCDH+CINF(J)*(HINF(J)-DELHIF(J))/HREF           ENRG 56
SUMCHF=SUMCHF+CINF(J)*HFAC(J)/CPREF                       ENRG 57
CONTINUE                                                    ENRG 58
C
CALCULATE SLIP VARIABLES                                  ENRG 59
C
CS1=SP*XNS*(SUMCHF)/(EPS*EPS*CGNO)                         ENRG 60
CS2=-SP*XNS*(0.50*(URSH-CP)**2+0.50*(SP**2-VRSH**2)+SUMCDH)/(EPS*EENRG 61
1PS*CONO*TTS2)                                             ENRG 62
E1=0.0                                                      ENRG 63
F1=TW/TTS2                                                  ENRG 64
C
CALL SOLVE (T1,T2,E1,F1,CRNI,1.00,CS1,CS2,SSFAC)          ENRG 65
C
TTS2G=TTS2                                                  ENRG 66
SMALL=1.0E-6                                                ENRG 67
DO 30 N=2,IE                                               ENRG 68
IF (T2(N).LE.0.0) T2(N)=SMALL                             ENRG 69
CONTINUE                                                    ENRG 70
CALL DERIV3 (T2,XN,IE,1,Q1)                                ENRG 71
T2NIE=Q1(IE)                                               ENRG 72
IF (SSFAC) 70,70,40                                        ENRG 73
TPSH=T2NIE                                                  ENRG 74
TTS2=T2(IE)*TTS2G                                           ENRG 75
IF (S.GE.0.0001) GO TO 50                                  ENRG 76
TTS1=TTS2                                                    ENRG 77
TTS=(TTS2+TTS1)/2.0                                         ENRG 78
DO 60 N=1,IE                                               ENRG 79
T2(N)=T2(N)*TTS2G/TTS2                                     ENRG 80
ENRG 81
ENRG 82
ENRG 83
ENRG 84
ENRG 85
ENRG 86
ENRG 87
ENRG 88

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	GO TO 80	ENRG 89
70	TPSH=0.0	ENRG 90
80	CCONTINUE	ENRG 91
	XU25=U2(15)	ENRG 92
	DO 120 N=1,IE	ENRG 93
	R2(N)=P2(N)*EMBAR(N)/(T2(N)*EMBAR(IE))	ENRG 94
	IF (S.GE.0.0001) GO TO 100	ENRG 95
	IF (NITER.GT.20) GO TO 90	ENRG 96
	R1(N)=R2(N)	ENRG 97
	T1(N)=T2(N)	ENRG 98
	GO TO 100	ENRG 99
90	CCONTINUE	ENRG 100
	R1(N)=UFAC*R1(N)+(1.0-UFAC)*R2(N)	ENRG 101
	T1(N)=UFAC*T1(N)+(1.0-UFAC)*T2(N)	ENRG 102
100	TC(N)=(T1(N)+T2(N))/2.	ENRG 103
C		ENRG 104
C	CALCULATE PROFILE DIFFERENCE	ENRG 105
C		ENRG 106
	IF (T21(N).EQ.0.00) GO TO 110	ENRG 107
	DIFF=ABS(1.00-T2(N)/T21(N))	ENRG 108
	IF (DIFF.GT.DIFI(2)) DIFI(2)=DIFF	ENRG 109
110	CCONTINUE	ENRG 110
	T21(N)=T2(N)	ENRG 111
	VC(N)=VCD(N)/VVS	ENRG 112
120	RC(N)=(R2(N)+R1(N))/2.0	ENRG 113
	CALL DERIV3 (TC,XN,IE,1,Q1)	ENRG 114
	TCNW=Q1(1)	ENRG 115
	RETURN	ENRG 116
	END	ENRG 117

	SUBROUTINE GEOM (S,DS,RS,CK,CSF,SIF,XB)	GEOM 1
C		GEOM 2
C	SUBROUTINE GEOM CALCULATES THE BODY GEOMETRY	GEOM 3
C		GEOM 4
C	SUBROUTINE GEOM CALLS SUBROUTINE SMOOTH.	GEOM 5
C		GEOM 6
C	SUBROUTINE GEOM IS CALLED BY MAIN.	GEOM 7
C		GEOM 8
	COMMON /BODY/ HANGLE,XJFAC,IGEOM,JFAC	GEOM 9
	COMMON /KJI/ IJK	GEOM 10
	DIMENSION ZAX(301), RWA(301), SUR(301), CKA(301), THA(301)	GEOM 11
	DATA KBL/1H /	GEOM 12
	IRN4=4	GEOM 13
	GO TO (40,10,70), IGEOM	GEOM 14
C		GEOM 15
C	IGEOM = 1 HYPERBOLOID	GEOM 16
C	= 2 PARABOLOID	GEOM 17
C	= 3 CURVE FIT	GEOM 18
C		GEOM 19
C		GEOM 20
C	PARABOLOID	GEOM 21
C		GEOM 22
10	CCONTINUE	GEOM 23
	XS=S+DS	GEOM 24
	DR=DS/SQRT(1.00+RS*RS)	GEOM 25
	REXP=RS+DR	GEOM 26
	DELTA=1.00	GEOM 27
20	CCONTINUE	GEOM 28
	IF (ABS(DELTA).LE.0.00000010) GO TO 30	GEOM 29
	RFAC=SQRT(1.00+REXP*REXP)	GEOM 30
	DELTA=(XS-0.50*REXP*RFAC-0.50*ALOG(REXP+RFAC))/RFAC	GEOM 31
	REXP=REXP+DELTA	GEOM 32
	GO TO 20	GEOM 33
30	CCONTINUE	GEOM 34
	XB=REXP*REXP/2.00	GEOM 35
	RS=REXP	GEOM 36

	DRX=1.00/SQRT(1.00+RS*RS)	GEOM 37
	CSF=RS/SQRT(1.00+RS*RS)	GEOM 38
	SIF=DRX	GEOM 39
	CK=SIF**3	GEOM 40
	RETURN	GEOM 41
40	CCONTINUE	GEOM 42
C		GEOM 43
C	FOR A HYPERBOLOID ASYMPTOTIC TO A CONE OF TOTAL INTERIOR ANGLE	GEOM 44
C	OF (2. * HANGLE) DEGREES	GEOM 45
C		GEOM 46
	ANG=HANGLE/57.2957795	GEOM 47
	CT1=ATAN(ANG)**2	GEOM 48
	CT2=1.00+CT1	GEOM 49
	DERR=DS*SQRT(CT1*RS*RS+1.0)/SQRT(CT2*RS*RS+1.0)	GEOM 50
	REXP=RS+DERR/2.00	GEOM 51
50	CCONTINUE	GEOM 52
	DERR=DS*SQRT(CT1*REXP*REXP+1.0)/SQRT(CT2*REXP*REXP+1.0)	GEOM 53
	DELT=RS+DERR/2.00-REXP	GEOM 54
	IF (DELT.LE.C.00001) GO TO 60	GEOM 55
	REXP=RS+DERR/2.00	GEOM 56
	GC TO 50	GEOM 57
60	RS=RS+DERR	GEOM 58
	SQPT=SQRT(1.00+CT2*RS*RS)	GEOM 59
	XB=(-1.00+SQRT(1.00+CT1*RS*RS))/CT1	GEOM 60
	CK=1.00/(SQPT*SQPT*SQPT)	GEOM 61
	CSF=RS/SQPT	GEOM 62
	SIF=SQRT(1.00-CSF*CSF)	GEOM 63
	RETURN	GEOM 64
C		GEOM 65
C	CURVE FIT OF PIECEWISE CONTINUOUS FUNCTION	GEOM 66
C		GEOM 67
70	CCONTINUE	GEOM 68
	IF (IJK.EQ.123) GO TO 110	GEOM 69
	I=0	GEOM 70
80	CONTINUE	GEOM 71
	I=I+1	GEOM 72
	IF (I.EQ.302) GO TO 90	GEOM 73
	READ (IRN4,120) ZAX(I),RWA(I),SUR(I),CKA(I),THA(I),KND	GEOM 74
	IF (KND-KBL) 100,80,100	GEOM 75
90	CCONTINUE	GEOM 76
	I=I-1	GEOM 77
	WRITE (6,130) SUR(I)	GEOM 78
100	CONTINUE	GEOM 79
	IJK=123	GEOM 80
	NX=I	GEOM 81
110	CCONTINUE	GEOM 82
	S=S+DS	GEOM 83
	CALL INTRP3 (S,SUR,ZAX,NX,XB)	GEOM 84
	CALL INTRP3 (S,SUR,RWA,NX,RS)	GEOM 85
	CALL INTRP3 (S,SUR,CKA,NX,CK)	GEOM 86
	CALL INTRP3 (S,SUR,THA,NX,THC)	GEOM 87
	CSF=COS(THC)	GEOM 88
	SIF=SIN(THC)	GEOM 89
	S=S-DS	GEOM 90
	RETURN	GEOM 91
C		GEOM 92
C		GEOM 93
C		GEOM 94
120	FORMAT (5E15.6,A1)	GEOM 95
130	FORMAT (1H0,79HWARNING - CURVE FIT GEOMETRY DATA EXCEEDS ARRAY STORAGE; IMAGE; DATA TRUNCATED AT S = ,1PE13.6//)	GEOM 96
	END	GEOM 97
		GEOM 98

	SUBROUTINE HCP (TR,CPII,HII,HIFAC)	HCP	1
C		HCP	2
C	SUBROUTINE HCP INTERPOLATES FOR ENTHALPY AND SPECIFIC HEAT	HCP	3
C	FOR ONE TEMPERATURE	HCP	4
C		HCP	5
C	SUBROUTINE HCP CALLS SUBROUTINE INTER3.	HCP	6
C		HCP	7
C	SUBROUTINE HCP IS CALLED BY SUBROUTINES ENERGY, SHVALS, AND THERM.	HCP	8
C		HCP	9
	COMMON /COMFSA/ CINF(6),CPIFS(6),DELHIF(6),HINF(6)	HCP	10
	COMMON /COMNS/ NS	HCP	11
	COMMON /COMSML/ SMALLT	HCP	12
	COMMON /COMTAB/ CPTAB(50,6),HTAB(50,6),TMPTAB(50),NTAB	HCP	13
	DIMENSION HIFAC(6)	HCP	14
	DIMENSION CPII(6), HII(6)	HCP	15
C		HCP	16
C	TR - DEGREES R	HCP	17
C		HCP	18
	FAC=1.0+SMALLT	HCP	19
	JC=0	HCP	20
10	JC=JC+1	HCP	21
	IF (JC.GT.NTAB) GO TO 20	HCP	22
	IF (TR.GT.TMPTAB(JC)*FAC) GO TO 10	HCP	23
20	CONTINUE	HCP	24
	IF (JC.LT.2) JC=2	HCP	25
	IF (JC.GT.(NTAB-1)) JC=NTAB-1	HCP	26
	DO 30 J=1,NS	HCP	27
	CALL INTER3 (TR,TMPTAB(JC-1),TMPTAB(JC),TMPTAB(JC+1),HTAB(JC-1,J),	HCP	28
	HTAB(JC,J),HTAB(JC+1,J),HIFAC(J))	HCP	29
	CALL INTER3 (TR,TMPTAB(JC-1),TMPTAB(JC),TMPTAB(JC+1),CPTAB(JC-1,J)	HCP	30
	1,CPTAB(JC,J),CPTAB(JC+1,J),CPII(J))	HCP	31
	HII(J)=HIFAC(J)*TR+DELHIF(J)	HCP	32
30	CONTINUE	HCP	33
C		HCP	34
C	CPII - FT**2/SEC**2-DEGR	HCP	35
C	HII - FT**2/SEC**2	HCP	36
C		HCP	37
	RETURN	HCP	38
	END	HCP	39

	SUBROUTINE HCPA (TA,IE,HREF,CPREF,TTS,TREF,HI,CPI)	HCPA	1
C		HCPA	2
C	SUBROUTINE HCPA INTERPOLATES FOR ENTHALPY AND SPECIFIC HEAT	HCPA	3
C	FOR AN ARRAY OF TEMPERATURES	HCPA	4
C		HCPA	5
C	SUBROUTINE HCPA CALLS SUBROUTINE INTER3.	HCPA	6
C		HCPA	7
C	SUBROUTINE HCPA IS CALLED BY SUBROUTINE THERM.	HCPA	8
C		HCPA	9
	COMMON /COMFSA/ CINF(6),CPIFS(6),DELHIF(6),HINF(6)	HCPA	10
	COMMON /COMNS/ NS	HCPA	11
	COMMON /COMSML/ SMALLT	HCPA	12
	COMMON /COMTAB/ CPTAB(50,6),HTAB(50,6),TMPTAB(50),NTAB	HCPA	13
	DIMENSION TA(51)	HCPA	14
	DIMENSION HI(51,6)	HCPA	15
	DIMENSION CPI(51,6)	HCPA	16
C		HCPA	17
C	TR - DEGREES R	HCPA	18
C		HCPA	19
	FAC=1.0+SMALLT	HCPA	20
	DO 40 N=1,IE	HCPA	21
	TR=TA(N)*TTS*TREF	HCPA	22
	JC=0	HCPA	23
10	JC=JC+1	HCPA	24
	IF (JC.GT.NTAB) GO TO 20	HCPA	25
	IF (TR.GT.TMPTAB(JC)*FAC) GO TO 10	HCPA	26
20	CONTINUE	HCPA	27

	IF (JC.LT.2) JC=2	HCPA	28
	IF (JC.GT.(NTAB-1)) JC=NTAB-1	HCPA	29
	DO 30 J=1,NS	HCPA	30
	CALL INTER3 (TR,TMPTAB(JC-1),TMPTAB(JC),TMPTAB(JC+1),HTAB(JC-1,J),HCPA	HCPA	31
	1HTAB(JC,J),HTAB(JC+1,J),HIFAC)	HCPA	32
	CALL INTER3 (TR,TMPTAB(JC-1),TMPTAB(JC),TMPTAB(JC+1),CPTAB(JC-1,J)HCPA	HCPA	33
	1,CPTAB(JC,J),CPTAB(JC+1,J),CPIFAC)	HCPA	34
	HI(N,J)=(HIFAC*TR+DELHIF(J))/HREF	HCPA	35
	CPI(N,J)=CPIFAC/CPREF	HCPA	36
30	CONTINUE	HCPA	37
40	CONTINUE	HCPA	38
	RETURN	HCPA	39
	END	HCPA	40

	SUBROUTINE INTERP (XX,XN,F2,IE,FF)	INTP	1
C		INTP	2
C		INTP	3
C	SUBROUTINE INTERP USES FUNCTION TLU TO INTERPOLATE IN ARRAY F2	INTP	4
C	FOR THE VALUE FF CORRESPONDING TO THE VALUE XX IN ARRAY XN.	INTP	5
C	IF XX .LT. XN(1) .OR. XX .GT. XN(IE), FF IS SET EQUAL TO F2(IE)	INTP	6
C	AND A MESSAGE IS PRINTED.	INTP	7
C		INTP	8
C	SUBROUTINE INTERP IS CALLED BY SUBROUTINE VPRFLE.	INTP	9
C		INTP	10
C	SUBROUTINE INTERP CALLS FUNCTION TLU.	INTP	11
C		INTP	12
C	DIMENSION XN(IE), F2(IE)	INTP	13
C		INTP	14
C		INTP	15
	FF=TLU(IE,F2,XN,XX,NFLAG)	INTP	16
	IF (NFLAG.NE.1) RETURN	INTP	17
	WRITE (6,10)	INTP	18
	FF=F2(IE)	INTP	19
	RETURN	INTP	20
C		INTP	21
C		INTP	22
C		INTP	23
10	FORMAT (1H0,10X,38HINADAQUATE TABLE FOR SUBROUTINE INTEPP, //11X,43INTP	INTP	24
	1HSTANDARD FIXUP TAKEN - EXECUTICN CONTINUING)	INTP	25
	END	INTP	26

	SUBROUTINE INTER3 (X,X1,X2,X3,F1,F2,F3,F)	INT3	1
C		INT3	2
C	SUBROUTINE INTER3 INTERPOLATES FOR THE VALUE F CORRESPONDING TO	INT3	3
C	POINT X USING 3 POINT LAGRANGIAN INTERPOLATION.	INT3	4
C		INT3	5
C	SUBROUTINE INTER3 IS CALLED BY SUBROUTINES INTRP3, HCP, AND HCPA.	INT3	6
C		INT3	7
C	ASSUMES X1 .LE. X .LE. X3.	INT3	8
C		INT3	9
	AN1=(X-X2)*(X-X3)	INT3	10
	AN2=(X-X1)*(X-X3)	INT3	11
	AN3=(X-X1)*(X-X2)	INT3	12
	DN1=(X1-X2)*(X1-X3)	INT3	13
	DN2=(X2-X1)*(X2-X3)	INT3	14
	DN3=(X3-X1)*(X3-X2)	INT3	15
	CN1=AN1/DN1	INT3	16
	CN2=AN2/DN2	INT3	17
	CN3=AN3/DN3	INT3	18
	F=CN1*F1+CN2*F2+CN3*F3	INT3	19
	RETURN	INT3	20
	END	INT3	21

	SUBROUTINE INTRPS (XX,YY,X,Y,NP,NNU,DYY)	INTS	1
C		INTS	2
C	SUBROUTINE INTRPS CALLS SUBROUTINE SMOOTH.	INTS	3
C		INTS	4
C	SUBROUTINE INTRPS IS CALLED BY SUBROUTINE SMTHPR.	INTS	5
C		INTS	6
	COMMON /COMSPL/ SMALLT	INTS	7
C		INTS	8
C	USES SUBROUTINE SMOOTH TO INTERPOLATE FOR YY IN ARRAY Y	INTS	9
C	CCRRESPONDING TO XX IN ARRAY X	INTS	10
C		INTS	11
C	NP = NUMBER OF POINTS IN ARRAYS	INTS	12
C	NU = 1/2 OF THE NUMBER OF POINTS TO BE USED IN SMOOTH	INTS	13
C	NNU = PREFERRED VALUE OF NU	INTS	14
C		INTS	15
	DIMENSION X(NP), Y(NP)	INTS	16
	FAC=1.0+SMALLT	INTS	17
	JC=0	INTS	18
10	JC=JC+1	INTS	19
	IF (XX.GT.X(JC)*FAC) GO TO 10	INTS	20
	NU=NNU	INTS	21
	NFAC=NP-JC+1	INTS	22
	IF (NFAC.LE.NU) NU=NFAC	INTS	23
	IF (JC.LE.NU) NU=JC	INTS	24
	IF (NU.LE.0) NU=1	INTS	25
	CALL SMOOTH (XX,X,Y,NP,YY,DYY,NU,DDYY)	INTS	26
	RETURN	INTS	27
	END	INTS	28
	SUBROUTINE INTRP3 (XX,X,Y,NPNTS,YY)	ITR3	1
C		ITR3	2
C	SUBROUTINE INTRP3 SETS UP THE CALLING ARGUMENT FOR	ITR3	3
C	SUBROUTINE INTER3	ITR3	4
C		ITR3	5
C	SUBROUTINE INTRP3 CALLS SUBROUTINE INTER3.	ITR3	6
C		ITR3	7
C	SUBROUTINE INTRP3 IS CALLED BY MAIN.	ITR3	8
C		ITR3	9
C	YY IS THE VALUE RETURNED FROM ARRAY Y	ITR3	10
C	WHICH CORRESPONDS TO THE VALUE XX IN ARRAY X	ITR3	11
C		ITR3	12
	COMMON /COMSPL/ SMALLT	ITR3	13
	DIMENSION X(NPNTS), Y(NPNTS)	ITR3	14
C		ITR3	15
	FAC=1.0+SMALLT	ITR3	16
	JC=0	ITR3	17
10	JC=JC+1	ITR3	18
	IF (XX.GT.X(JC)*FAC) GO TO 10	ITR3	19
	IF (JC.LT.2) JC=2	ITR3	20
	IF (JC.GT.(NPNTS-1)) JC=NPNTS-1	ITR3	21
	CALL INTER3 (XX,X(JC-1),X(JC),X(JC+1),Y(JC-1),Y(JC),Y(JC+1),YY)	ITR3	22
	RETURN	ITR3	23
	END	ITR3	24
	SUBROUTINE MASS	MASS	1
C		MASS	2
C	SUBROUTINE MASS SOLVES THE MASS CONSERVATION EQUATION	MASS	3
C		MASS	4
C	SUBROUTINE MASS CALLS SUBROUTINE DERIV3.	MASS	5
C		MASS	6
C	SUBROUTINE MASS IS CALLED BY MAIN.	MASS	7
C		MASS	8
	COMMON /BODY/ HANGLE,XJFAC,IGECM,JFAC	MASS	9
	COMMON /COMAR1/ XNSP(202),XSOL(200)	MASS	10
	COMMON /COMAR1/ AA(51),BB(51),CAEQ(51),CON(51),COL(51),CO2(51),CPSMASS	MASS	11
	1T(51),EMBAR(51),PC(51),PCN(51),PE(51),PFAC(51),PS(51),PO(51),PON(5MASS	MASS	12
	21),P1(51),P1N(51),P2(51),P2N(51),Q1(51),Q2(51),RC(51),RCON(51),RCSMASS	MASS	13

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3F(51),RNSH(51),RVISC(51),R1(51),R2(51),TC(51),T1(51),T2(51),T20(51)MASS 14
4),T21(51),UC(51),UCN(51),UC1(51),U1(51),U2(51),U20(51),VC(51),VCO(MASS 15
551),VC11(51),VC12(51),VG(51),VGN(51),VGS(51),VISC(51),VS(51),VO(51)MASS 16
6),VON(51),V1(51),V2(51),V2N(51)MASS 17
COMMON /COMG/ CAT,CNS,CRNI,REFAC,SSFAC,SWFAC,THIN,VPG,I,K,NITER MASS 18
CCOMMON /COMG2/ CK,CK2,CSF2,RS2,SIF2,XB2,XNSPM MASS 19
CCOMMON /COMG3/ CSF,RS,SIF,XB,XNS1 MASS 20
COMMON /COMRX/ RSH,XSH MASS 21
CCOMMON /COMVSP/ VSPP1,VSPP2 MASS 22
COMMON /INSH/ CONO,S,UPSH,XNS,EPS,TPSH,VISCO MASS 23
COMMON /INV2/ XNSA,XNSIVO,XNSIV1,XNSTMP,NAN MASS 24
CCOMMON /OUTSH/ PPS,PPS1,PPS2,PSP,REYSH,RRS,RRS1,RRS2,RSP,TSP,TTS,TMASS 25
1TTS1,TTS2,USP,UUS,UUS1,UUS2,VSP,VVS,VVS1,VVS2 MASS 26
CCOMMON /SOLV/ A1(51),A2(51),A3(51),A4(51),DN(52),DS,XN(52),IE,IM MASS 27
C MASS 28
DO 10 N=2,IE MASS 29
AA(N)=AA(N-1)+DN(N-1)*(R2(N-1)*U2(N-1)+R2(N)*U2(N))/2. MASS 30
10 BB(N)=BB(N-1)+DN(N-1)*(R2(N-1)*U2(N-1)*XN(N-1)+R2(N)*U2(N)*XN(N))/MASS 31
12. MASS 32
IF (S.GE.0.0001) GO TO 30 MASS 33
C MASS 34
C STAGNATION PCINT MASS 35
C MASS 36
AIA=8.*BB(IE)*RRS2*UUS2*CSF2/DS-DS MASS 37
BIB=4.*AA(IE)*RRS2*UUS2*RS2/DS-DS MASS 38
CIC=-DS MASS 39
ROT=BIB*BIB-AIA*CIC MASS 40
XNS=(-BIB+SQRT(ROT))/AIA MASS 41
IF (XJFAC.LT.0.5) XNS=1.0/(RRS2*USP*AA(IE)-1.0) MASS 42
C MASS 43
C SHOCK-LAYER THICKNESS MASS 44
C MASS 45
XNS2=XNS1/2.0 MASS 46
XNST=XNS1*2.0 MASS 47
IF (XNS.GT.XNST) XNS=XNST MASS 48
IF (XNS.LE.0.0) XNS=XNS1 MASS 49
IF (XNS.LT.XNS2) XNS=XNS2 MASS 50
XNS=0.8*XNS1+0.2*XNS MASS 51
XNSTMP=XNS MASS 52
IF (NAN.EQ.-1) XNS=XNSTMP MASS 53
XNSIVO=0.0 MASS 54
XNSIV1=0.0 MASS 55
DO 20 N=1,IE MASS 56
C MASS 57
C NORMAL VELOCITY PROFILE MASS 58
C MASS 59
CO2(N)=XNS*(RS2**XJFAC*AA(N)+XNS*CSF2*XJFAC*BB(N))*RRS2*UUS2 MASS 60
VC(N)=8.*XNS*(AA(N)*RS2+XNS*BB(N)*CSF2)*RRS2*UUS2/(DS*DS*(1.+XNS*XMASS 61
1N(N))*2*RC(N)) MASS 62
IF (XJFAC.LT.0.5) VC(N)=XNS*AA(N)*RRS2*USP/((1.0+XNS*XN(N))*RC(N))MASS 63
20 CCNTINUE MASS 64
GO TO 50 MASS 65
C MASS 66
C S GREATER THAN ZERO MASS 67
C MASS 68
30 AIA=BB(IE)*CSF2*RRS2*UUS2 MASS 69
BIB=AA(IE)*RS2*RRS2*UUS2/2. MASS 70
CIC=-CO1(IE)+(RS+CNS*CSF)**XJFAC*((1.+CK*CNS)*RRS*VVS-XNSP(I))*RRS*UMASS 71
1US)*DS MASS 72
ROT=BIB*BIB-AIA*CIC MASS 73
XNS=(-BIB+SQRT(ROT))/AIA MASS 74
IF (XJFAC.LT.0.5) XNS=-CIC/(RRS2*UUS2*AA(IE)) MASS 75
C MASS 76
C SHOCK-LAYER THICKNESS MASS 77
C MASS 78
XNSIV1=0.0 MASS 79
AIA=CSF*(2.00*RRS*UUS*BB(IE)-CSF) MASS 80
BIB=RS*(RRS*UUS*AA(IE)-CSF) MASS 81
CIC=-RS**2 MASS 82
ROT=BIB*BIB-AIA*CIC MASS 83
XNSIVO=-BIB/AIA MASS 84

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	IF (ROT.GE.0.00) XNSIV1=XNSIVO+SQRT(ROT)/AIA	MASS	85
	IF (XJFAC.LT.0.5) XNSIV1=RS/(RRS*UUS*AA(IE)-CSF)	MASS	86
	XNS2=XNS1/2.0	MASS	87
	IF (XNS.LT.XNS2) XNS=XNS2	MASS	88
	XNSTMP=XNS	MASS	89
	XNSA=(XNSTMP+XNSIV1)/2.0	MASS	90
	IF (NAN.EQ.1) XNS=XNSIV1	MASS	91
	IF (NAN.EQ.0) XNS=XNSA	MASS	92
	IF (NAN.EQ.-1) XNS=XNSTMP	MASS	93
	IF (NAN.EQ.-2) XNS=XNSIV1	MASS	94
	DO 40 N=1, IE	MASS	95
C		MASS	96
C	NORMAL VELOCITY PROFILE	MASS	97
C		MASS	98
	CO2(N)=XNS*(RS2**XJFAC*AA(N)+XNS*CSF2*XJFAC*BB(N))*RRS2*UUS2	MASS	99
	VI=(CO2(N)-CO1(N))/DS	MASS	100
	VC(N)=-VI/(RRS*VVS*RC(N)*(1.+CK*CNS*XN(N))*(RS+CNS*XN(N)*CSF)**JF	MASS	101
	1C)+XNSP(I)*XN(N)*UUS*UC(N)/(VVS*(1.+CK*CNS*XN(N)))	MASS	102
40	CCNTINUE	MASS	103
50	CCNTINUE	MASS	104
	IF (S.GE.0.0001) GO TO 60	MASS	105
	XNS1=XNS	MASS	106
60	CNS=(XNS1+XNS)/2.	MASS	107
	XSH=XB-CNS*SIF	MASS	108
	RSH=RS+CNS*CSF	MASS	109
	IF (THIN.GE.0.0) GO TO 70	MASS	110
	IF (NITER.GT.1) GO TO 70	MASS	111
	VPG=(VSPP1+VSPP2)/2.0	MASS	112
70	CONTINUE	MASS	113
	DO 110 N=1, IE	MASS	114
	IF (THIN.GE.0.0) GO TO 80	MASS	115
	IF (NITER.GT.1) GO TO 80	MASS	116
	VGS(N)=(VCI2(N)-VCI1(N))/DS	MASS	117
	VG(N)=(VCI1(N)+VCI2(N))/2.	MASS	118
80	CCNTINUE	MASS	119
	RNSH(N)=CNS/(1.+CK*CNS*XN(N))	MASS	120
	IF (S.GE.0.0001) GO TO 90	MASS	121
	V1(N)=VC(N)	MASS	122
	RCSF(N)=CNS/(1.+CK*CNS*XN(N))	MASS	123
	GO TO 100	MASS	124
90	RCSF(N)=CSF*CNS/(RS+CNS*XN(N)*CSF)	MASS	125
100	V2(N)=VC(N)	MASS	126
	VCD(N)=VC(N)*VVS	MASS	127
110	VS(N)=(V2(N)-V1(N))/DS	MASS	128
	IF (THIN.GE.0.0) GO TO 120	MASS	129
	CALL DERIV3 (VO,XN,IE,1,VON)	MASS	130
	CALL DERIV3 (VG,XN,IE,1,VGN)	MASS	131
120	CALL DERIV3 (V2,XN,IE,1,V2N)	MASS	132
	RETURN	MASS	133
	END	MASS	134
	SUBROUTINE NMOMNT	NMNT	1
C		NMNT	2
C	SUBROUTINE NMCMNT SOLVES THE N MOMENT EQUATION	NMNT	3
C		NMNT	4
C	SUBROUTINE NMOMNT CALLS SUBROUTINE SHVALS.	NMNT	5
C		NMNT	6
C	SUBROUTINE NMCMNT IS CALLED BY MAIN.	NMNT	7
C		NMNT	8
	COMMON /COMARL/ XNSP(2G2),XSOL(200)	NMNT	9
	COMMON /COMAR1/ AA(51),BB(51),CAEQ(51),CON(51),CO1(51),CO2(51),CPSNMNT	10	
	1T(51),EMBAR(51),PC(51),PCN(51),PE(51),PFAC(51),PS(51),PQ(51),PON(51)	11	
	21),P1(51),P1N(51),P2(51),P2N(51),Q1(51),Q2(51),RC(51),RCON(51),RCSNMNT	12	
	3F(51),RNSH(51),RVISC(51),R1(51),R2(51),TC(51),T1(51),T2(51),T20(51)	13	
	4),T21(51),UC(51),UCN(51),UC1(51),U1(51),U2(51),U20(51),VC(51),VCD(NMNT	14	
	551),VCI1(51),VCI2(51),VG(51),VGN(51),VGS(51),VISC(51),VS(51),VO(51)	15	
	6),VON(51),V1(51),V2(51),V2N(51)	16	

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COMMON /COMG/ CAT,CNS,CRNI,REFAC,SSFAC,SWFAC,THIN,VPG,I,K,NITER NMNT 17
COMMON /COMG2/ CK,CK2,CSF2,RS2,SIF2,XB2,XNSPM NMNT 18
COMMON /COMS0/ PPS0,TTSO,VVS0,UUS0,NSOLD NMNT 19
COMMON /INSH/ CONO,S,UPSH,XNS,EPS,TPSH,VISCO NMNT 20
COMMON /OUTSH/ PPS,PPS1,PPS2,PSP,REYSH,RRS,RRS1,RRS2,RSP,TSP,TTS,TNMNT 21
1TS1,TT2,USP,UUS,UUS1,UUS2,VSP,VVS,VVS1,VVS2 NMNT 22
COMMON /SOLV/ A1(51),A2(51),A3(51),A4(51),DN(52),DS,XN(52),IE,IM NMNT 23
C NMNT 24
C NMNT 25
C DIMENSION P21(51), P21N(51), P22(51), P22N(51), P33(51), P33N(51) NMNT 26
C NMNT 27
C SET EDGE VALUES NMNT 28
C NMNT 29
C P21N(IE)=RRS2*UUS2**2*CK2*XNS/(PPS2*(1.+CK2*XNS)) NMNT 30
P21(IE)=1.0 NMNT 31
P22N(IE)=-RRS2*VVS*VVS*((1.-UUS2*XNSP(1)/(VVS*(1.+CK2*XNS)))*V2N( NMNT 32
1IE)+UUS2*XNS*VSP/VVS/(VVS*(1.+CK2*XNS)))/PPS2 NMNT 33
P22(IE)=0.0 NMNT 34
P2N(IE)=P21N(IE) NMNT 35
P2(IE)=1. NMNT 36
RC(IE)=1.0 NMNT 37
IF (THIN.GE.0.0) GO TO 10 NMNT 38
P33N(IE)=-RRS2*VVS2*VVS2*((1.-UUS2*XNSPM/(VVS2*(1.+CK2*XNS)))*VGN( NMNT 39
1IE)+UUS2*XNS*VPG/VVS2/(VVS2*(1.+CK2*XNS)))/PPS2 NMNT 40
P33(IE)=0.0 NMNT 41
P2N(IE)=P2N(IE)+P33N(IE) NMNT 42
10 CCNTINUE NMNT 43
PC(IE)=1. NMNT 44
PCN(IE)=(P1N(IE)+P2N(IE))/2. NMNT 45
IF (S.LE.0.0001) GO TO 20 NMNT 46
PFAC(IE)=(-XNSP(1)*PCN(IE)/CNS+PSP/PPS)/UUS NMNT 47
20 CCNTINUE NMNT 48
PE(IE)=1. NMNT 49
PS(IE)=0. NMNT 50
R2(IE)=1. NMNT 51
IF (S.GE.0.0001) GO TO 40 NMNT 52
CALL SHVALS (1.00,0.00,1.00,0.00,TTSO,VVS0,UUS0,PPS0,1) NMNT 53
PON(IE)=0.0 NMNT 54
IF (THIN.GE.0.0) GO TO 30 NMNT 55
PON(IE)=VVS0*VON(IE)/PPS0 NMNT 56
30 CCNTINUE NMNT 57
PC(IE)=1.0 NMNT 58
P1(IE)=1. NMNT 59
P1N(IE)=P2N(IE) NMNT 60
R1(IE)=1. NMNT 61
V1(IE)=1. NMNT 62
40 KCA=IM NMNT 63
SMALL=1.0E-6 NMNT 64
C NMNT 65
C CALCULATE DERIVATIVE NMNT 66
C NMNT 67
C DO 80 N=1,IM NMNT 68
C NMNT 69
C INTEGRATE, TRAPAZOIDAL RULE, FROM THE SHOCK TO THE BODY NMNT 70
C NMNT 71
C P21N(KON)=RRS2*UUS2**2*CK2*XNS*R2(KON)*U2(KON)**2/(PPS2*(1.+CK2*XNS NMNT 72
1S*XN(KON))) NMNT 73
C NMNT 74
C TVSL CONTRIBUTION NMNT 75
C NMNT 76
C P21(KON)=P21(KON+1)-DN(KON)*(P21N(KON+1)+P21N(KON))/2. NMNT 77
P22N(KON)=-RRS2*VVS*VVS*((R2(KON)*V2(KON)-R2(KON)*U2(KON)*UUS2*XNS NMNT 78
1P(1)*XN(KON)/(VVS*(1.+CK2*XNS*XN(KON))))*V2N(KON)+UUS2*XNS*R2(KON) NMNT 79
2*U2(KON)*(VS(KON)+VSP*V2(KON)/VVS)/(VVS*(1.+CK2*XNS*XN(KON)))/PPS NMNT 80
32 NMNT 81
C NMNT 82
C PSEUDO - FVSL CONTRIBUTION NMNT 83
C NMNT 84
C P22(KON)=P22(KON+1)-DN(KON)*(P22N(KON+1)+P22N(KON))/2. NMNT 85
P2N(KON)=P21N(KON) NMNT 86
P2(KON)=P21(KON) NMNT 87

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	IF (P2(KON).LT.SMALL) P2(KON)=SMALL	NMNT	88
	IF (THIN.GE.0.0) GO TO 50	NMNT	89
C		NMNT	90
C	FVSL CONTRIBUTION	NMNT	91
C		NMNT	92
	P33N(KON)=-RRS2*VVS2*VVS2*((R2(KON)*VG(KON)-R2(KON)*U2(KON)*UUS2*XNMNT		93
	INSPM*XN(KON)/(VVS2*(1.+CK2*XNS*XN(KON))) *VGN(KON)+UUS2*XNS*R2(KONNMNT		94
	2)*U2(KON)*(VGS(KON)+VPG*VG(KCN)/VVS2)/(VVS2*(1.+CK2*XNS*XN(KON)))NMNT		95
	3/PPS2	NMNT	96
	P33(KON)=P33(KON+1)-DN(KON)*(P33N(KON+1)+P33N(KON))/2.	NMNT	97
	P2N(KON)=P2N(KON)+P33N(KON)	NMNT	98
	P2(KCN)=P2(KGN)+P33(KCN)	NMNT	99
	IF (P2(KON).LT.SMALL) P2(KCN)=SMALL	NMNT	100
50	CONTINUE	NMNT	101
	R2(KCN)=P2(KCN)*EMBAR(KCN)/(T2(KON)*EMBAR(IE))	NMNT	102
	IF (S.GE.0.0001) GO TO 70	NMNT	103
	PON(KON)=0.0	NMNT	104
	IF (THIN.GE.0.0) GO TO 60	NMNT	105
	PON(KCN)=VVSU*PG(KON)*VO(KCN)*VON(KON)/(PPSO*T2(KON))*(EMBAR(KON)/NMNT		106
	1EMBAR(IE))	NMNT	107
60	CONTINUE	NMNT	108
	PO(KCN)=PO(KON+1)-DN(KON)*(PON(KON+1)+PON(KON))/2.	NMNT	109
	P1(KGN)=P2(KCN)	NMNT	110
	P1N(KCN)=P2N(KCN)	NMNT	111
	R1(KCN)=R2(KON)	NMNT	112
	V1(KCN)=V2(KGN)	NMNT	113
70	PE(KON)=P21(KON)+P22(KON)	NMNT	114
	PC(KCN)=(P1(KGN)+P2(KCN))/2.	NMNT	115
	RC(KCN)=(R2(KCN)+R1(KCN))/2.0	NMNT	116
	PCN(KON)=(P1N(KON)+P2N(KON))/2.	NMNT	117
	PS(KON)=(P2(KON)-P1(KON))/CS	NMNT	118
	IF (S.LE.0.0001) GO TO 80	NMNT	119
	PFAC(KON)=(PS(KON)-XNSP(I)*XN(KON)*PCN(KCN)/CNS+PSP*PC(KON)/PPS)/UNMNT		120
	1US	NMNT	121
80	KCA=KON-1	NMNT	122
	RETURN	NMNT	123
	END	NMNT	124

	SUBROUTINE RSET	RSET	1
C		RSET	2
C	SUBROUTINE RSET PRINTS THE SOLUTION DATA AND RESETS VARIABLES	RSET	3
C	FOR THE NEXT SOLUTION STATION	RSET	4
C		RSET	5
C	SUBROUTINE RSET IS CALLED BY MAIN.	RSET	6
C		RSET	7
	COMMON /COMARL/ XNSP(202),XSOL(200)	RSET	8
	COMMON /COMAR1/ AA(51),BB(51),CAEQ(51),CON(51),COL(51),CD2(51),CPSRSET		9
	1T(51),EMBAR(51),PC(51),PCN(51),PE(51),PFAC(51),PS(51),PO(51),PON(51RSET		10
	21),P1(51),P1N(51),P2(51),P2N(51),Q1(51),Q2(51),RC(51),RCON(51),RCSRSET		11
	3F(51),RNSH(51),RVISC(51),R1(51),R2(51),TC(51),T1(51),T2(51),T20(51RSET		12
	4),T21(51),UC(51),UCN(51),UC1(51),U1(51),U2(51),U20(51),VC(51),VCD(RSET		13
	551),VCI1(51),VCI2(51),VG(51),VGN(51),VGS(51),VISC(51),VS(51),VO(51RSET		14
	6),VON(51),V1(51),V2(51),V2N(51)	RSET	15
	COMMON /COMBC/ CAINF,CAW,CINF6(6),CIHW6(6)	RSET	16
	COMMON /COMDBL/ AJB(51,6),AJM(51,6),CC(51,6),CCL(51,6),CCN(51,6),CRSET		17
	1PI(51,6),C1(51,6),C2(51,6),C20(51,6),DW(51,6),HI(51,6),W0(51,6),W1RSET		18
	2(51,6)	RSET	19
	COMMON /COMFS/ PINF,REYIN,RINF,TINF,UINF	RSET	20
	COMMON /COMFSA/ CINF(6),CPIFS(6),DELHIF(6),HINF(6)	RSET	21
	COMMON /COMG/ CAT,CNS,CRNI,REFAC,SSFAC,SWFAC,THIN,VPG,I,K,NITER	RSET	22
	COMMON /COMG2/ CK,CK2,CSF2,RS2,SIF2,XB2,XNSPM	RSET	23
	COMMON /COMG3/ CSF,RS,SIF,XB,XNS1	RSET	24
	COMMON /COMNS/ NS	RSET	25
	COMMON /COMPRF/ SPRF(10),NSPRF	RSET	26
	COMMON /COMREF/ CONREF,CPREF,HREF,PREF,RREF,TREF,UREF,VSREF,WREF	RSET	27
	COMMON /COMRX/ RSH,XSH	RSET	28
	COMMON /COMSML/ SMALLT	RSET	29
	COMMON /COMSUM/ CPJSUM(51),HDWSUM(51),HWSUM(51),HJSUMW	RSET	30

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COMMON /COMVS/ EMI(6),VSA(6),VSB(6),VSC(6),R,NSPI(6) RSET 31
COMMON /COMW/ CIW(6),CIWW(6),CPIW(6),HIW(6),HTFLB,TB,TCNW,TW RSET 32
COMMON /COMXR/ ALP,ALT,BRAD,BO,CDF,CDFD,CDF1,CDF2,CDP,CDPD,CDP1,CORSET 33
1P2,OLDSLP,PHI,SEND,WVFAC,XNSO,IEND,IUN,KPLTTP,NITMIN,NITTOT,NTOT,NRSET 34
2TPL,NTW RSET 35
COMMON /INSH/ CONO,S,UPSH,XNS,EPS,TPSH,VISCO RSET 36
COMMON /INV2/ XNSA,XNSIVO,XNSIVI,XNSTMP,NAN RSET 37
COMMON /KNTR/ KNTRI,KNTW1,KNTW2 RSET 38
CCMMGN /OUTSH/ PPS,PPS1,PPS2,PSP,REYSH,RRS,RRS1,RRS2,RSP,TSP,TTS,TRSET 39
1TTS1,TTS2,USP,UUS,UUS1,UUS2,VSP,VVS,VVS1,VVS2 RSET 40
COMMON /PRLE/ SIGM,XLE RSET 41
CCMMGN /SOLV/ A1(51),A2(51),A3(51),A4(51),DN(52),DS,XN(52),IE,IM RSET 42
COMMON /TITLE/ KTITLE(20) RSET 43
DIMENSION TA(51) RSET 44
DIMENSION XM(51), ED(51) RSET 45
DATA BLNK/2H /,BNO/2HNC/ RSET 46
C RSET 47
IF (S.GE.0.0001) GO TO 20 RSET 48
CRNI=1.00 RSET 49
XNSO=CNS RSET 50
SUM=0.0 RSET 51
DC 10 J=1,NS RSET 52
10 SUM=SUM+CINF(J)*HINF(J) RSET 53
HTINF=0.5+SUM/HREF RSET 54
C RSET 55
C GLCBAL ITERATION HEADER DATA RSET 56
C RSET 57
WRITE (6,180) UINF,PINF,TINF,CAINF,TB,BRAD,SIGM,XLE,XNSO,ALT RSET 58
CNT=BLNK RSET 59
CWS=BLNK RSET 60
CSS=BLNK RSET 61
CCA=BLNK RSET 62
IF (THIN.EQ.-1.) CNT=BNO RSET 63
IF (SWFAC.EQ.-1.) CWS=BNO RSET 64
IF (SSFAC.EQ.-1.) CSS=BNO RSET 65
IF (CAT.EQ.-1.) CCA=BNO RSET 66
WRITE (6,190) CNT,CWS,CSS,CCA,IE,IEND,DS RSET 67
IF (NSPRF.NE.0) WRITE (6,200) (SPRF(NK),NK=1,NSPRF) RSET 68
WRITE (6,210) BO,EPS,REYIN,REYSH,TREF,UREF,RREF,PREF,K RSET 69
20 REFAC=RRS*VVS*CNS/(EPS*EPS*VISCO) RSET 70
CFCH=2.*UUS*RRS*VVS*VISC(1)*(UCA(1)-CK*CNS*UC(1))/REFAC RSET 71
HEAT=TTS*RRS*VVS*(CONO*CON(1)*TCNW/VISCO+UUS*UUS*VISC(1)*UC(1)*UCNRSET 72
1(1)/TTS)/REFAC+EPS*EPS*HJSUMW/CNS RSET 73
STAN=HEAT/(HTINF-HTFLB) RSET 74
XNSP(1)=(XNS-XNS1)/DS RSET 75
EDMAX=0.0 RSET 76
NEDMAX=1 RSET 77
DC 70 N=1,IE RSET 78
IF (I.GT.1) GO TO 40 RSET 79
VO(N)=VC(N) RSET 80
U20(N)=U2(N) RSET 81
T20(N)=T2(N) RSET 82
DO 30 J=1,NS RSET 83
C20(N,J)=C2(N,J) RSET 84
30 CONTINUE RSET 85
40 CONTINUE RSET 86
GAMN=CPST(N)*CPREF/(CPST(N)*CPREF-R/EMBAR(N)) RSET 87
GAMMM1=GAMN-1.0 RSET 88
C RSET 89
C MACH NUMBER PROFILE RSET 90
C RSET 91
XM(N)=SQRT((UUS*UUS*UC(N)*UC(N)+VVS*VVS*VC(N)*VC(N))/((GAMMM1)*TTSRSET 92
1*TC(N))) RSET 93
TA(N)=TC(N)*TTS*TREF RSET 94
IF (NS.EQ.2) GO TO 50 RSET 95
C RSET 96
C ELECTRON NUMBER DENSITY PROFILE RSET 97
C RSET 98
ED(N)=0.515360*RC(N)*RRS*RREF*CC(N,5)*6.025E23/EMI(5) RSET 99
IF (EDMAX.LT.ED(N)) NEDMAX=N RSET 100
IF (EDMAX.LT.ED(N)) EDMAX=ED(N) RSET 101

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50	CONTINUE	RSET 102
	U1(N)=U2(N)	RSET 103
	V1(N)=V2(N)	RSET 104
	T1(N)=T2(N)	RSET 105
	SUM=0.0	RSET 106
	DO 60 J=1,NS	RSET 107
	SUM=SUM+CC(N,J)*HI(N,J)	RSET 108
	C1(N,J)=C2(N,J)	RSET 109
60	CONTINUE	RSET 110
	R1(N)=R2(N)	RSET 111
	P1(N)=P2(N)	RSET 112
	IF (THIN.GE.0.0) VCI2(N)=VC(N)	RSET 113
	IF (THIN.LT.0.0) VCI2(N)=WVFAC*VC(N)+(1.0-WVFAC)*VCI1(N)	RSET 114
70	CQ1(N)=CQ2(N)	RSET 115
	XNEDMX=XN(NEDMAX)	RSET 116
	YEDMAX=XNEDMX*XNS*BRAD*12.0	RSET 117
	DO 80 N=1,IE	RSET 118
80	VCI2(N)=VCI2(N)/VCI2(IE)	RSET 119
	IF (ABS(VVS).LE.0.0100) GO TO 90	RSET 120
C		RSET 121
C	WRITE NORMAL PROFILE TO DISC	RSET 122
C		RSET 123
	WRITE (NTW) S,VVS,VSP,VCI2	RSET 124
	KNTW1=KNTW1+1	RSET 125
90	CONTINUE	RSET 126
	PWALL=PPS*PC(1)	RSET 127
	IF (S.LE.0.0001) GO TO 100	RSET 128
	CDP2=4.*RS*SIF*PWALL	RSET 129
	CDP2=2.*RS*CSF*CFCH	RSET 130
	CDPD=CDPD+(CDP1+CDP2)*DS/2.	RSET 131
	CDFD=CDFD+(CDF1+CDF2)*DS/2.	RSET 132
	CDP=CDPD/(RS*RS)	RSET 133
	CDF=CDFD/(RS*RS)	RSET 134
100	IF (S.GE.0.0001) GO TO 110	RSET 135
	HEATO=HEAT	RSET 136
	PWALO=PWALL	RSET 137
	CDF=0.0	RSET 138
	CDP=2.0*PWALL	RSET 139
110	CDTOT=CDF+CDP	RSET 140
	CDP1=CDP2	RSET 141
	CDF1=CDF2	RSET 142
	QDCT=HEAT*RINF*UINF**3/778.00	RSET 143
	QQO=HEAT/HEATO	RSET 144
	PWRAT=PWALL/PWALO	RSET 145
	XNS1=XNS	RSET 146
	UUS1=UUS2	RSET 147
	VVS1=VVS2	RSET 148
	TTS1=TTS2	RSET 149
	PPS1=PPS2	RSET 150
	RRS1=RRS2	RSET 151
	XSOL(I)=S	RSET 152
	AVSLP=(OLDSLP+XNSP(I))/2.0	RSET 153
	SRN=S*BRAD	RSET 154
C		RSET 155
C	PRINT SOLUTION DATA	RSET 156
C		RSET 157
	WRITE (6,360) KTITLE	RSET 158
	WRITE (6,250) S,XB,RS,CNS,XNSP(I),XSH,RSH,NITER,NITTOT,NTOT,I,K	RSET 159
	WRITE (8,240) XNSP(I),XNS,XSH,RSH	RSET 160
	TWALL=TW*TREF	RSET 161
	WRITE (6,260) DS,CFCH,HEAT,STAN,CDF,CDP,CDTOT,PWALL,TWALL,PWRAT	RSET 162
	WRITE (1,320) K,I,S,NITER,XNS,XNSP(I),CFCH,HEAT,STAN,PWRAT,QQO,SRN	RSET 163
	1,QDOT	RSET 164
	IF (KPLTTP.NE.0) WRITE (NTPL) K,I,XSOL(I),XB,RS,XSH,RSH,CNS,CFCH,SRN	RSET 165
	1TAN,PWRAT	RSET 166
	WRITE (3,330) K,I,NITER,S,XNS,XNSTMP,XNSIV1,XNSA,EDMAX,XNEDMX,YEDMR	RSET 167
	1AX,S,SRN	RSET 168
	WRITE (6,270)	RSET 169
	WRITE (6,280) OLDSLP,XNSPM,XNSP(I),ALP,PHI,CK,CK2	RSET 170
	WRITE (6,290) UUS,VVS,TTS,RRS,PPS,VPG	RSET 171
	USHSTR=UUS*UREF	RSET 172

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VSHSTR=VVS*UREF                                RSET 173
TSHSTR=TTT*TREF                                RSET 174
TSHSTK=TSHSTR/1.80                             RSET 175
WRITE (6,300) USHSTR,VSHSTR,TSHSTR              RSET 176
WRITE (6,310) TSHSTK                             RSET 177
IF (ABS(1.00-S/SEND).LE.SMALLT) GO TO 140        RSET 178
IF (NSPRF.EQ.0) GO TO 130                        RSET 179
DO 120 NK=1,NSPRF                                RSET 180
IF (S.EQ.0.00) GO TO 140                         RSET 181
IF (SPRF(NK).EQ.0.00) GO TO 120                  RSET 182
IF (ABS(1.00-S/SPRF(NK)).LE.SMALLT) GO TO 140    RSET 183
120 CONTINUE                                     RSET 184
130 CONTINUE                                     RSET 185
IF ((I+4)/5*5.NE.(I+4)) GO TO 170               RSET 186
140 CONTINUE                                     RSET 187
C                                                  RSET 188
C PRINT PROFILES                                RSET 189
C                                                  RSET 190
WRITE (6,220)                                    RSET 191
WRITE (6,230) (N,XN(N),UC(N),VC(N),TC(N),RC(N),PC(N),PE(N),CC(N,1) RSET 192
1,CAEQ(N),XM(N),TA(N),N=1,IE)                   RSET 193
IF (NS.EQ.2) GO TO 160                           RSET 194
WRITE (6,340) (NSP1(J),J=1,NS)                   RSET 195
DO 150 N=1,IE                                     RSET 196
YORN=XN(N)*XNS                                    RSET 197
YIN=YORN*BRAD*12.00                              RSET 198
YCM=YIN*2.540                                    RSET 199
WRITE (6,350) N,YORN,(CC(N,J),J=1,NS),ED(N),YIN,YCM RSET 200
150 CONTINUE                                     RSET 201
160 CONTINUE                                     RSET 202
170 CONTINUE                                     RSET 203
RETURN                                             RSET 204
C                                                  RSET 205
C                                                  RSET 206
C                                                  RSET 207
180 FORMAT (1H1, //5X,4HUINF,8X,4HPINF,10X,4HTINF,10X,5HCAINF,7X,2HTB,1RSET 208
11X,4HBRAD,9X,2HPR,9X,2HLE,9X,3HYSH,10X,3HALT/1X,E12.3,2E14.5,E12.3RSET 209
2,2E13.4,2E11.2,E13.4,E12.3)                     RSET 210
190 FORMAT (1H0,A2,17H THIN SHOCK LAYER,2X,A2,10H WALL SLIP,2X,A2,11H RSET 211
1SHOCK SLIP,2X,A2,9H CAT WALL,15H NO STEPS IN Y=,I3,15H NO STEPS INRSET 212
2 S=,I3,13H S STEP SIZE=,F5.3)                   RSET 213
200 FORMAT (1H0,31HSOLUTIONS TO BE OBTAINED AT S =,10F9.2)    RSFT 214
210 FORMAT (1H0,3X,5HTW/TS,4X,3HEPS,6X,6HREYINF,7X,5HREYSH,8X,4HTREF,9RSET 215
1X,4HUREF,9X,4HRRREF,9X,4HPREF,6X,4HITER/1X,F7.4,F9.4,6E13.4,I4) RSET 216
220 FCRMAT (1H0,2X,1HN,4X,5HY/YSH,6X,5HU/USH,6X,5HV/VSH,6X,5HT/TSH,7X,RSET 217
15HR/RSH,5X,11HP/PSH(APPR),3X,5HP/PSH,7X,2HCA,10X,4HCAEQ,8X,3H XM,9RSET 218
2X,7HT DEG R)                                     RSET 219
230 FORMAT (1X,I3,2F11.6,F12.6,F11.6,6F12.6,F12.2) RSET 220
240 FORMAT (1H ,64X,4F15.10)                       RSET 221
250 FORMAT (1H0,5X,1HS,11X,1HX,11X,1HR,11X,3HYSH,9X,4HYSHP,8X,3HXSH,9XRSET 222
1,3HRSH,5X,7HNO ITER,4X,6HNITTOT,4X,4HNTOT,3X,1HI,5X,1HK/7F12.6,I6,RSET 223
27X,I5,4X,I5,2X,I3,4X,I1)                         RSET 224
260 FORMAT (1H0,5X,2HDS,10X,2HCF,10X,4HHEAT,8X,4HSTAN,8X,3HCDF,9X,3HCDRSET 225
1P,9X,5HCDTOT,7X,5HPWALL,7X,5HTWALL,7X,5HPW/PO/10F12.6) RSET 226
270 FCRMAT (1H0,2X,8HYSHP ( S,2X,13HYSHP ( S+DS/2,2X,8HNEW YSHP,2X,12HRSET 227
1ALPHA(S+DS/2,1X,10HPhi(S+DS/2,3X,7HKAPPA(S,2X,12HKAPPA(S+DS/2) RSET 228
280 FORMAT (1H ,7F12.6)                             RSET 229
290 FORMAT (1H0,8X,3HUSH,10X,3HVSH,10X,3HTSH,10X,3HRSH,10X,3HPSH,10X,3RSET 230
1HVP/3X,6F13.6)                                    RSET 231
300 FORMAT (3X,3F13.2)                             RSET 232
310 FORMAT (3X,26X,F13.2//)                         RSET 233
320 FCRMAT (2X,I1,2X,I3,F12.6,1X,I4,9F12.6)         RSET 234
330 FORMAT (2X,I1,2X,I3,1X,I4,5F12.6,1PE12.4,OPF12.6,3F12.6) RSET 235
340 FORMAT (1H0,4X,1HN,4X,4HY/RN,6(9X,A4),10X,5HE-/CC,6X,4HY IN,9X,4HYRSET 236
1 CM)                                                RSET 237
350 FCRMAT (1H ,1X,I3,F13.5,7E13.5,2F12.5)         RSET 238
360 FORMAT (///5X,6H**** ,20A4,6H ****//)          RSET 239
END                                                  RSET 240

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	SUBROUTINE RTEDTA	RDTA 1
C		RDTA 2
C	SUBROUTINE RTEDTA READS THE REACTION RATE DATA FROM UNIT IUN	RDTA 3
C	FOR DISSOCIATING OXYGEN AND MULTI-COMPONENT AIR	RDTA 4
C		RDTA 5
C	SUBROUTINE RTEDTA IS CALLED BY MAIN.	RDTA 6
C		RDTA 7
	COMMON /COMSET/ RATE2(15,6),RATE6(15,6),ZSUB2(5,6),ZSUB6(5,6),KRTITL(18),KREQ2(15,6),NAME2(11),NJ2,NR2,NZ2,KREQ6(15,6),NAME6(11),NJ6	RDTA 8
	RDTA 9	RDTA 10
	COMMON /COMXR/ ALP,ALT,BRAD,BO,CDF,CDFD,CDF1,CDF2,CDP,CDPD,CDP1,CDRDTA	RDTA 11
	IP2,OLDSLP,PHI,SEND,WVFAC,XNSC,IEND,IUN,KPLTTP,NITMIN,NITTOT,NTOT,NRDTA	RDTA 12
	2TPL,NTW	RDTA 13
	DATA KTST/3HLOG/	RDTA 14
	NS2=2	RDTA 15
	NS6=6	RDTA 16
	DO 10 I=1,6	RDTA 17
	DC 10 J=1,5	RDTA 18
	ZSUB2(J,I)=0.	RDTA 19
	ZSUB6(J,I)=0.	RDTA 20
13	CCONTINUE	RDTA 21
	READ (IUN,80) (KRTITL(I),I=1,18)	RDTA 22
C		RDTA 23
C	DISSOCIATING CXYGEN	RDTA 24
C		RDTA 25
	READ (IUN,90) NJ2,NR2,NZ2	RDTA 26
	READ (IUN,100) (NAME2(I),I=1,NJ2)	RDTA 27
	DO 20 I=1,NR2	RDTA 28
	READ (IUN,110) (KREQ2(I,J),J=1,6),(RATE2(I,K),K=1,6)	RDTA 29
	IF (KTST.NE.KRTITL(1)) GO TO 20	RDTA 30
	RATE2(I,1)=ALCG(RATE2(I,1))	RDTA 31
	RATE2(I,4)=ALOG(RATE2(I,4))	RDTA 32
20	CCONTINUE	RDTA 33
	NZ2=NJ2-NS2	RDTA 34
	IF (NZ2.LE.0) GO TO 40	RDTA 35
	DO 30 I=1,NZ2	RDTA 36
30	READ (IUN,120) (ZSUB2(I,J),J=1,NS2)	RDTA 37
C		RDTA 38
C	MULTI-COMPONENT AIR	RDTA 39
C		RDTA 40
40	READ (IUN,90) NJ6,NR6,NZ6	RDTA 41
	READ (IUN,100) (NAME6(I),I=1,NJ6)	RDTA 42
	DO 50 I=1,NR6	RDTA 43
	READ (IUN,110) (KREQ6(I,J),J=1,6),(RATE6(I,K),K=1,6)	RDTA 44
	IF (KTST.NE.KRTITL(1)) GO TO 50	RDTA 45
	RATE6(I,1)=ALOG(RATE6(I,1))	RDTA 46
	RATE6(I,4)=ALCG(RATE6(I,4))	RDTA 47
50	CCONTINUE	RDTA 48
	NZ6=NJ6-NS6	RDTA 49
	IF (NZ6.LE.0) GO TO 70	RDTA 50
	DO 60 I=1,NZ6	RDTA 51
60	READ (IUN,120) (ZSUB6(I,J),J=1,NS6)	RDTA 52
70	CCONTINUE	RDTA 53
	RETURN	RDTA 54
C		RDTA 55
C		RDTA 56
C		RDTA 57
80	FORMAT (A3,17A4)	RDTA 58
90	FORMAT (3I3,7I1X)	RDTA 59
100	FORMAT (20A4)	RDTA 60
110	FORMAT (6(I1X,A4),2(E10.0,F6.0,F4.0),10X)	RDTA 61
120	FORMAT (6F10.5,20X)	RDTA 62
	END	RDTA 63

	SUBROUTINE SET	SET	1
C		SET	2
C	SUBROUTINE SET INITIALIZES THE PROFILES FOR EACH GLOBAL ITERATION	SET	3
C		SET	4
C	SUBROUTINE SET CALLS SUBROUTINE DERIV3.	SET	5
C		SET	6
C	SUBROUTINE SET IS CALLED BY MAIN.	SET	7
C		SET	8
	COMMON /COMAR1/ AA(51),BB(51),CAEQ(51),CON(51),CO1(51),CO2(51),CPSSET	SET	9
	1T(51),EMBAR(51),PC(51),PCN(51),PE(51),PFAC(51),PS(51),PO(51),PON(51)	SET	10
	21),P1(51),P1N(51),P2(51),P2N(51),Q1(51),Q2(51),RC(51),RCN(51),RCSSET	SET	11
	3F(51),RNSH(51),RVISC(51),R1(51),R2(51),TC(51),T1(51),T2(51),T20(51)	SET	12
	4),T21(51),UC(51),UCN(51),UC1(51),U1(51),U2(51),U20(51),VC(51),VCD(51)	SET	13
	551),VCI1(51),VCI2(51),VG(51),VGN(51),VGS(51),VISC(51),VS(51),VO(51)	SET	14
	6),VON(51),V1(51),V2(51),V2N(51)	SET	15
	COMMON /COMDBL/ AJB(51,6),AJM(51,6),CC(51,6),CCL(51,6),CCN(51,6),CSET	SET	16
	1PI(51,6),C1(51,6),C2(51,6),C20(51,6),DW(51,6),HI(51,6),WO(51,6),W1SET	SET	17
	2(51,6)	SET	18
	COMMON /COMEDG/ CIE(6),TCIE	SET	19
	COMMON /COMFSA/ CINF(6),CPIFS(6),DELHIF(6),HINF(6)	SET	20
	COMMON /COMG/ CAT,CNS,CRNI,REFAC,SSFAC,SWFAC,THIN,VPG,I,K,NITER	SET	21
	COMMON /COMG2/ CK,CK2,CSF2,RS2,SIF2,XB2,XNSPM	SET	22
	COMMON /COMNS/ NS	SET	23
	COMMON /COMSO/ PPSO,TTSO,VVSO,UUSO,NSOLD	SET	24
	COMMON /COMW/ CIW(6),CIWW(6),CPIW(6),HIW(6),HTFLB,TB,TCNW,TW	SET	25
	COMMON /SOLV/ A1(51),A2(51),A3(51),A4(51),DN(52),DS,XN(52),IE,IM	SET	26
C		SET	27
	DO 20 N=1,IE	SET	28
	RNSH(N)=CNS/(1.+CK*CNS*XN(N))	SET	29
	RCSF(N)=CNS/(1.+CK*CNS*XN(N))	SET	30
	U1(N)=XN(N)	SET	31
	IF (K.GT.1) U1(N)=U20(N)	SET	32
	U2(N)=U1(N)	SET	33
	UC(N)=U1(N)	SET	34
	UC1(N)=U2(N)	SET	35
	V1(N)=XN(N)	SET	36
	IF (THIN.LE.0.0) V1(N)=VO(N)	SET	37
	V2(N)=V1(N)	SET	38
	VC(N)=V1(N)	SET	39
	IF (THIN.GT.0.00.AND.K.EQ.1) VO(N)=0.00	SET	40
	VCD(N)=VC(N)*VVSO	SET	41
	T1(N)=1.0-(1.0-XN(N))*(1.0-Tw/TTSO)	SET	42
	IF (K.GT.1) T1(N)=T20(N)	SET	43
	T2(N)=T1(N)	SET	44
	TC(N)=T1(N)	SET	45
	T21(N)=T2(N)	SET	46
	P1(N)=1.0	SET	47
	P2(N)=1.0	SET	48
	PC(N)=1.0	SET	49
	PE(N)=1.0	SET	50
	PS(N)=0.0	SET	51
	PO(N)=1.0	SET	52
	PON(N)=0.0	SET	53
	R1(N)=P1(N)/T1(N)	SET	54
	R2(N)=R1(N)	SET	55
	RC(N)=R1(N)	SET	56
	CAEQ(N)=0.0	SET	57
	CPST(N)=1.0	SET	58
	PFAC(N)=1.0	SET	59
	PCN(N)=0.0	SET	60
	P1N(N)=0.0	SET	61
	P2N(N)=0.0	SET	62
	DO 10 J=1,NS	SET	63
	C1(N,J)=CINF(J)	SET	64
	IF (NS.EQ.NSOLD) C1(N,J)=C20(N,J)	SET	65
	C2(N,J)=C1(N,J)	SET	66
	CC(N,J)=C1(N,J)	SET	67
	CCL(N,J)=CC(N,J)	SET	68
10	CONTINUE	SET	69
20	CONTINUE	SET	70

	DO 30 J=1,NS	SET	71
	CIW(J)=CC(1,J)	SET	72
30	CIE(J)=CC(IE,J)	SET	73
	CALL DERIV3 (UC,XN,IE,1,UCN)	SET	74
	DO 60 J=1,NS	SET	75
	DO 40 N=1,IE	SET	76
40	Q1(N)=C1(N,J)	SET	77
	CALL DERIV3 (Q1,XN,IE,1,Q2)	SET	78
	DO 50 N=1,IE	SET	79
	CCN(N,J)=Q2(N)	SET	80
50	CCONTINUE	SET	81
60	CONTINUE	SET	82
	RETURN	SET	83
	END	SET	84

	SUBROUTINE SET2	SET2	1
C		SET2	2
C	SUBROUTINE SET2 SETS THE FREESTREAM AND WALL SPECIES CONCENTRA-	SET2	3
C	TIONS AND SETS THE STOICHIOMETRIC COEFFICIENT ARRAYS	SET2	4
C		SET2	5
C	SUBROUTINE SET2 IS CALLED BY MAIN.	SET2	6
C		SET2	7
	DIMENSION INAME(20), IREACT(20,6)	SET2	8
	COMMON /COMABZ/ ALPHSB(15,11),BETASB(15,11),ZSUB(5,6),ALSUB(15),BE	SET2	9
	ITSUB(15),GAMMMI(15,6),GAMMPL(15,6)	SET2	10
	COMMON /COMBC/ CAINF,CAW,CINF(6),CIWW(6)	SET2	11
	COMMON /COMFSA/ CINF(6),CPIFS(6),DELHIF(6),HINF(6)	SET2	12
	COMMON /COMNS/ NS	SET2	13
	COMMON /COMNS2/ NJ,NR,NSM1,NZ	SET2	14
	COMMON /COMSET/ RATE2(15,6),RATE6(15,6),ZSUB2(5,6),ZSUB6(5,6),KRTI	SET2	15
	1TL(18),KREQ2(15,6),NAME2(11),NJ2,NR2,NZ2,KREQ6(15,6),NAME6(11),NJ6	SET2	16
	2,NR6,NZ6	SET2	17
	COMMON /COMW/ CIW(6),CIWW(6),CPIW(6),HIW(6),HTFLB,TB,TCNW,TW	SET2	18
	COMMON /RTECON/ CRO(15),CRI(15),CR2(15),DRO(15),DRI(15),DR2(15)	SET2	19
	DATA IBLANK/4H /	SET2	20
	DO 10 I=1,20	SET2	21
	INAME(I)=IBLANK	SET2	22
	DO 10 J=1,6	SET2	23
	IREACT(I,J)=IBLANK	SET2	24
10	CCONTINUE	SET2	25
	DO 20 J=1,11	SET2	26
	DO 20 KR=1,15	SET2	27
	ALPHSB(KR,J)=0.0	SET2	28
	BETASB(KR,J)=0.0	SET2	29
20	CCONTINUE	SET2	30
	DO 30 N=1,6	SET2	31
	DO 30 J=1,5	SET2	32
	ZSUB(J,N)=0.0	SET2	33
30	CCONTINUE	SET2	34
	IF (NS.NE.2) GO TO 70	SET2	35
C		SET2	36
C	DISSOCIATING OXYGEN	SET2	37
C		SET2	38
	NJ=NJ2	SET2	39
	NR=NR2	SET2	40
	NZ=NJ-NS	SET2	41
	CINF(1)=CAINF	SET2	42
	CINF(2)=1.00-CAINF	SET2	43
	CIWW(1)=CAW	SET2	44
	CIWW(2)=1.00-CAW	SET2	45
	DO 40 I=1,NJ	SET2	46
40	INAME(I)=NAME2(I)	SET2	47

	DO 50 I=1,NR	SET2 48
	CR0(I)=RATE2(I,1)	SET2 49
	CR1(I)=RATE2(I,2)	SET2 50
	CR2(I)=RATE2(I,3)	SET2 51
	DRO(I)=RATE2(I,4)	SET2 52
	DR1(I)=RATE2(I,5)	SET2 53
	DR2(I)=RATE2(I,6)	SET2 54
	DO 50 J=1,6	SET2 55
50	IReact(I,J)=KREQ2(I,J)	SET2 56
	NN2=NJ-NZ	SET2 57
	IF (NZ.LE.0) GO TO 110	SET2 58
	IF (NN2.LE.0) GO TO 110	SET2 59
	DO 60 I=1,NZ	SET2 60
	DO 60 J=1,NN2	SET2 61
60	ZSUB(I,J)=ZSUB2(I,J)	SET2 62
	GO TO 110	SET2 63
70	CCNTINUE	SET2 64
C		SET2 65
C	MULTI-COMPONENT AIR	SET2 66
C		SET2 67
	NJ=NJ6	SET2 68
	NR=NR6	SET2 69
	NZ=NJ-NS	SET2 70
	DO 80 I=1,NJ	SET2 71
80	INAME(I)=NAME6(I)	SET2 72
	DO 90 I=1,NR	SET2 73
	CR0(I)=RATE6(I,1)	SET2 74
	CR1(I)=RATE6(I,2)	SET2 75
	CR2(I)=RATE6(I,3)	SET2 76
	DRO(I)=RATE6(I,4)	SET2 77
	DR1(I)=RATE6(I,5)	SET2 78
	DR2(I)=RATE6(I,6)	SET2 79
	DO 90 J=1,6	SET2 80
	CINF(J)=CINF6(J)	SET2 81
	CIWW(J)=CIWW6(J)	SET2 82
90	IReact(I,J)=KREQ6(I,J)	SET2 83
	NN2=NJ-NZ	SET2 84
	IF (NZ.LE.0) GO TO 110	SET2 85
	DO 100 I=1,NZ	SET2 86
	DO 100 J=1,NN2	SET2 87
100	ZSUB(I,J)=ZSUB6(I,J)	SET2 88
110	CCNTINUE	SET2 89
C		SET2 90
C	STOICHIOMETRIC COEFFICIENT ARRAYS	SET2 91
C		SET2 92
	DO 130 I=1,NR	SET2 93
	DO 130 K=1,NJ	SET2 94
	DO 130 J=1,3	SET2 95
	IF (INAME(K).NE.IReact(I,J)) GO TO 120	SET2 96
	ALPHSB(I,K)=ALPHSB(I,K)+1.0	SET2 97
120	IF (INAME(K).NE.IReact(I,J+3)) GO TO 130	SET2 98
	BETASB(I,K)=BETASB(I,K)+1.0	SET2 99
130	CCNTINUE	SET2 100
	DO 150 KR=1,NR	SET2 101
	ALSUB(KR)=0.00	SET2 102
	BETSUB(KR)=0.00	SET2 103
	DO 140 J=1,NJ	SET2 104
	ALSUB(KR)=ALSUB(KR)+ALPHSB(KR,J)	SET2 105
140	BETSUB(KR)=BETSUB(KR)+BETASB(KR,J)	SET2 106
	ALSUB(KR)=ALSUB(KR)-1.00	SET2 107
150	BETSUB(KR)=BETSUB(KR)-1.00	SET2 108
	DO 200 KR=1,NR	SET2 109
	DO 190 J=1,NS	SET2 110
	IF (BETASB(KR,J)-ALPHSB(KR,J)) 160,170,180	SET2 111
160	GAMMPL(KR,J)=0.00	SET2 112
	GAMMMI(KR,J)=-(BETASB(KR,J)-ALPHSB(KR,J))	SET2 113
	GO TO 190	SET2 114
170	GAMMPL(KR,J)=0.00	SET2 115
	GAMMMI(KR,J)=0.00	SET2 116
	GO TO 190	SET2 117
180	GAMMPL(KR,J)=BETASB(KR,J)-ALPHSB(KR,J)	SET2 118

	GAMMMI(KR,J)=0.00	SET2 119
190	CCNTINUE	SET2 120
200	CCNTINUE	SET2 121
C		SET2 122
C	PRINT REACTION RATE DATA AND ARRAYS	SET2 123
C		SET2 124
	WRITE (6,280) (KRTITL(I),I=1,18)	SET2 125
	WRITE (6,290)	SET2 126
	DO 210 I=1,NR	SET2 127
	EXPCRO=EXP(CRO(I))	SET2 128
	EXPDR0=EXP(DRO(I))	SET2 129
210	WRITE (6,300) I,(IREACT(I,J),J=1,6),CRO(I),EXPCRO,CR1(I),CR2(I),DR	SET2 130
	IO(I),EXPDR0,DR1(I),DR2(I)	SET2 131
C		SET2 132
C	ALPHSB(NR,NJ) AND BETASB(NR,NJ)	SET2 133
C		SET2 134
	WRITE (6,310) NR,NJ,(INAME(I),I=1,NJ)	SET2 135
	DO 220 I=1,NR	SET2 136
220	WRITE (6,320) I,ALSUB(I),I,(ALPHSB(I,J),J=1,NJ)	SET2 137
	WRITE (6,330) NR,NJ,(INAME(I),I=1,NJ)	SET2 138
	DO 230 I=1,NR	SET2 139
230	WRITE (6,320) I,BETSUB(I),I,(BETASB(I,J),J=1,NJ)	SET2 140
	IF (NZ.LE.0) GO TO 250	SET2 141
C		SET2 142
C	ZSUB(NZ,NS)	SET2 143
C		SET2 144
	WRITE (6,340) NZ,NN2,(INAME(I),I=1,NN2)	SET2 145
	DO 240 I=1,NZ	SET2 146
	NN1=NN2+I	SET2 147
240	WRITE (6,350) INAME(NN1),(ZSUB(I,J),J=1,NN2)	SET2 148
250	CCNTINUE	SET2 149
C		SET2 150
C	GAMMPL(NR,NS) AND GAMMMI(NR,NS)	SET2 151
C		SET2 152
	WRITE (6,360) NR,NS	SET2 153
	DO 260 I=1,NR	SET2 154
260	WRITE (6,370) I,(GAMMPL(I,J),J=1,NS)	SET2 155
	WRITE (6,380) NR,NS	SET2 156
	DO 270 I=1,NR	SET2 157
270	WRITE (6,370) I,(GAMMMI(I,J),J=1,NS)	SET2 158
	RETURN	SET2 159
C		SET2 160
C		SET2 161
C		SET2 162
280	FORMAT (//1H0,A3,17A4)	SET2 163
290	FORMAT (4H0NR,13X,8HREACTION,17X,3HCRO,8X,8HEXP(CRO),8X,3HCR1,8X,	SET2 164
	13HCR2,7X,3HDRO,8X,8HEXP(DRO),10X,3HDR1,6X,3HDR2)	SET2 165
300	FORMAT (1H,I2,2X,3(1X,A4),1H=,3(A4,1X),2(2X,F12.7,1X,E11.4,3X,2(1	SET2 166
	1X,F8.1),1X))	SET2 167
310	FORMAT (1H0,18X,7HALPHSB(I2,1H,,I2,1H),/,3H NR,3X,5HALSUB,7X,2HNR	SET2 168
	1,4X,20(2X,A4))	SET2 169
320	FORMAT (1H,I2,1X,F6.1,8X,I2,2X,20(2X,F4.0))	SET2 170
330	FORMAT (1H0,18X,7HBETASB(I2,1H,,I2,1H),/,3H NR,2X,6HBETSUB,6X,2HNS	SET2 171
	1R,4X,20(2X,A4))	SET2 172
340	FORMAT (19H0,ZSUB(I2,1H,,I2,1H),/,1H0,6X,20(2X,A4))	SET2 173
350	FORMAT (1H,A4,20(2X,F4.1))	SET2 174
360	FORMAT (11H0 GAMMPL(I2,1H,,I2,1H))	SET2 175
370	FORMAT (1H,I2,15(2X,F4.0))	SET2 176
380	FORMAT (11H0 GAMMMI(I2,1H,,I2,1H))	SET2 177
	END	SET2 178

	SUBROUTINE SHVALS (SP,CP,SPB,CPB,TTSH,VRSH,URSH,PPSH,ID)	SHVL	1
C		SHVL	2
C	SUBROUTINE SHVALS CALCULATES THE PROPERTIES BEHIND THE SHOCK	SHVL	3
C		SHVL	4
C	SUBROUTINE SHVALS CALLS SUBROUTINES HCP, AND VISCON.	SHVL	5
C		SHVL	6
C	SUBROUTINE SHVALS IS CALLED BY MAIN AND SUBROUTINE NMOMNT.	SHVL	7
C		SHVL	8
	COMMON /COMEDG/ CIE(6),TCIE	SHVL	9
	COMMON /COMFS/ PINF,REYIN,RINF,TINF,UINF	SHVL	10
	COMMON /CCMFSA/ CINF(6),CPIFS(6),DELHIF(6),HINF(6)	SHVL	11
	COMMON /COMNS/ NS	SHVL	12
	COMMON /COMREF/ CONREF,CPREF,HREF,PREF,RREF,TREF,UREF,VSREF,WREF	SHVL	13
	COMMON /COMVS/ EMI(6),VSA(6),VSB(6),VSC(6),R,NSPI(6)	SHVL	14
	COMMON /INSH/ CONO,S,UPSH,XNS,EPS,TPSH,VISCO	SHVL	15
	COMMON /OUTSH/ PPS,PPS1,PPS2,PSP,REYSH,RRS,RRS1,RRS2,RSP,TSP,TTS,TSHVL	SHVL	16
	1 TTS1,TTS2,USP,UUS,UUS1,UUS2,VSP,VVS,VVS1,VVS2	SHVL	17
	COMMON /SOLV/ A1(51),A2(51),A3(51),A4(51),DN(52),DS,XN(52),IE,IM	SHVL	18
C		SHVL	19
	DIMENSION HII(6), HFAC(6), CPII(6)	SHVL	20
C		SHVL	21
	CALL HCP (TCIE,CPII,HII,HFAC)	SHVL	22
	CALL VISCON (CIE,CPII,VSTIE,CSTIE,TCIE)	SHVL	23
	VISCO=VSTIE/VSREF	SHVL	24
	CONO=CSTIE/CONREF	SHVL	25
	TTS2TR=TTS2*TREF	SHVL	26
	CALL HCP (TTS2TR,CPII,HII,HFAC)	SHVL	27
	SUM1=0.0	SHVL	28
	SUMCDH=0.0	SHVL	29
	SUMCHF=0.0	SHVL	30
	DO 10 J=1,NS	SHVL	31
	SUM1=SUM1+CIE(J)/EMI(J)	SHVL	32
	SUMCDH=SUMCDH+CINF(J)*(HINF(J)-DELHIF(J))/HREF	SHVL	33
	SUMCHF=SUMCHF+CINF(J)*HFAC(J)/CPREF	SHVL	34
10	CCONTINUE	SHVL	35
	EMBARE=1.0/SUM1	SHVL	36
	RMCP=R/(EMBARE*CPREF)	SHVL	37
C		SHVL	38
	URSH=CP/(1.00+EPS**2*VISCO*UPSH/(XNS*SP))	SHVL	39
	TTSH=((0.50*(URSH-CP)**2+0.50*(SP**2-VRSH**2)+SUMCDH))/(SUMCHF+EPS	SHVL	40
	1**2*CONO*TPSH/(XNS*SP))	SHVL	41
	PPSH=PINF/(RINF*UINF**2)+SP*(VRSH+SP)	SHVL	42
	RRSH=PPSH/(TTSH*RMCP)	SHVL	43
	VRSH=-SP/RRSH	SHVL	44
	GO TO (40,20), ID	SHVL	45
20	CCONTINUE	SHVL	46
	TTS2=TTSH	SHVL	47
	PPS2=PPSH	SHVL	48
	RRS2=RRSH	SHVL	49
	UUS2=URSH*SPB+VRSH*CPB	SHVL	50
	VVS2=-URSH*CPB+VRSH*SPB	SHVL	51
	IF (S.GE..0001) GO TO 30	SHVL	52
	UUS1=-UUS2	SHVL	53
	VVS1=VVS2	SHVL	54
	TTS1=TTS2	SHVL	55
	PPS1=PPS2	SHVL	56
	RRS1=RRS2	SHVL	57
30	CCONTINUE	SHVL	58
	UUS=(UUS1+UUS2)/2.00	SHVL	59
	VVS=(VVS1+VVS2)/2.00	SHVL	60
	TTS=(TTS1+TTS2)/2.00	SHVL	61
	PPS=(PPS1+PPS2)/2.00	SHVL	62
	RRS=(RRS1+RRS2)/2.00	SHVL	63
	USP=(UUS2-UUS1)/DS	SHVL	64
	VSP=(VVS2-VVS1)/DS	SHVL	65
	TSP=(TTS2-TTS1)/DS	SHVL	66
	PSP=(PPS2-PPS1)/DS	SHVL	67
	RSP=(RRS2-RRS1)/DS	SHVL	68
40	CONTINUE	SHVL	69
	RETURN	SHVL	70
	END	SHVL	71

	SUBROUTINE SMCNNT	SMNT	1
C		SMNT	2
C	SUBROUTINE SMCNNT SOLVES THE S MOMENTUM EQUATION	SMNT	3
C		SMNT	4
C	SUBROUTINE SMOMNT CALLS SUBROUTINES DERIV3, AND SOLVE.	SMNT	5
C		SMNT	6
C	SUBROUTINE SMCNNT IS CALLED BY MAIN.	SMNT	7
C		SMNT	8
	COMMON /BODY/ HANGLE,XJFAC,IGECM,JFAC	SMNT	9
	COMMON /COMARL/ XNSP(202),XSOL(200)	SMNT	10
	COMMON /COMAR1/ AA(51),BB(51),CAEQ(51),CON(51),CO1(51),CO2(51),CPSSMNT	SMNT	11
	1T(51),EMBAR(51),PC(51),PCN(51),PE(51),PFAC(51),PS(51),PO(51),PON(51)	SMNT	12
	21),P1(51),P1A(51),P2(51),P2N(51),Q1(51),Q2(51),RC(51),RCON(51),RCSSMNT	SMNT	13
	3F(51),RNSH(51),RVISC(51),R1(51),R2(51),TC(51),T1(51),T2(51),T20(51)	SMNT	14
	4),T21(51),UC(51),UCN(51),UC1(51),U1(51),U2(51),U20(51),VC(51),VCD(51)	SMNT	15
	551),VCI1(51),VCI2(51),VG(51),VGN(51),VGS(51),VISC(51),VS(51),VO(51)	SMNT	16
	6),VON(51),V1(51),V2(51),V2N(51)	SMNT	17
	COMMON /COMFAC/ CCFAC,UFAC	SMNT	18
	COMMON /COMG/ CAT,CNS,CRNI,REFAC,SSFAC,SWFAC,THIN,VPG,I,K,NITER	SMNT	19
	COMMON /COMG1/ CP,CPB,SP,SPB	SMNT	20
	COMMON /COMG2/ CK,CK2,CSF2,RS2,SIF2,XB2,XNSPM	SMNT	21
	COMMON /COMTST/ DIFI(8),DIF,XU25	SMNT	22
	COMMON /COMUV/ URSH,VRSH	SMNT	23
	COMMON /INSH/ COND,S,UPSH,XNS,EPS,TPSH,VISCO	SMNT	24
	COMMON /OUTSH/ PPS,PPS1,PPS2,PSP,REYSH,RRS,RRS1,RRS2,RSP,TSP,TTS,TSMNT	SMNT	25
	1TS1,TTS2,USP,UUS,UUS1,UUS2,VSP,VVS,VVS1,VVS2	SMNT	26
	COMMON /SOLV/ A1(51),A2(51),A3(51),A4(51),DN(52),DS,XN(52),IE,IM	SMNT	27
C		SMNT	28
	DIMENSION U11(51)	SMNT	29
C		SMNT	30
	DO 10 N=1,IE	SMNT	31
C		SMNT	32
C	CALCULATE COEFFICIENTS FOR PARTIAL DIFFERENTIAL EQUATION	SMNT	33
C		SMNT	34
	A1(N)=REFAC*(UUS*XNSP(I)*RNSH(N)*RC(N)*UC(N)*XN(N)/(VVS*CNS)-RC(N)	SMNT	35
	1*VC(N))/VISC(N)+RVISC(N)+CK*RNSH(N)+RCSF(N)*XJFAC	SMNT	36
	A2(N)=-REFAC*(USP*RNSH(N)*RC(N)*UC(N)/VVS+CK*RNSH(N)*RC(N)*VC(N))/	SMNT	37
	1VISC(N)-CK*RNSH(N)*RVISC(N)-(CK*RNSH(N)+RCSF(N)*XJFAC)*CK*RNSH(N)	SMNT	38
	A3(N)=-REFAC*PPS*RNSH(N)*PFAC(N)/(VISC(N)*RRS*VVS)	SMNT	39
	A4(N)=-REFAC*UUS*RNSH(N)*RC(N)*UC(N)/(VISC(N)*VVS)	SMNT	40
10		SMNT	41
C		SMNT	42
C	CALCULATE SLIP VARIABLES	SMNT	43
C		SMNT	44
	CS1=SP*SPB*UUS2*XNS/(EPS*EPS*VISCO*URSH)-CK2*XNS/(1.+CK2*XNS)	SMNT	45
	CS2=-SP*XNS*(CP+VVS2*CPB)/(EPS*EPS*VISCO*URSH)	SMNT	46
	E1=0.0	SMNT	47
	F1=0.0	SMNT	48
C		SMNT	49
	CALL SOLVE (U1,U2,E1,F1,CRNI,1.00,CS1,CS2,SSFAC)	SMNT	50
C		SMNT	51
	ULS2G=UUS2	SMNT	52
	SMALL=1.0E-6	SMNT	53
	DO 20 N=2,IE	SMNT	54
	IF (U2(N).LE.0.0) U2(N)=SMALL	SMNT	55
	IF (U2(N).GT.1.15) U2(N)=1.15	SMNT	56
20	CONTINUE	SMNT	57
	CALL DERIV3 (U2,XN,IE,1,Q1)	SMNT	58
	U2NIE=Q1(IE)	SMNT	59
	IF (SSFAC) 60,60,30	SMNT	60
30	UPSH=U2NIE-CK2*XNS*U2(IE)/(1.+CK2*XNS)	SMNT	61
	UUS2=U2(IE)*UUS2G	SMNT	62
	IF (S.GE.0.0001) GO TO 40	SMNT	63
	UUS1=-UUS2	SMNT	64
40	UUS=(UUS2+UUS1)/2.0	SMNT	65
	DO 50 N=1,IE	SMNT	66
50	U2(N)=U2(N)*UUS2G/UUS2	SMNT	67
	GO TO 70	SMNT	68
60	UPSH=0.	SMNT	69
70	CONTINUE	SMNT	70
	DO 110 N=1,IE	SMNT	70

	U11(N)=U1(N)	SMNT	71
	IF (S.GE.0.0001) GO TO 90	SMNT	72
	IF (NITER.GT.20) GO TO 80	SMNT	73
	U1(N)=U2(N)	SMNT	74
	GO TO 90	SMNT	75
80	CONTINUE	SMNT	76
	U1(N)=UFAC*U1(N)+(1.0-UFAC)*U2(N)	SMNT	77
90	UC(N)=(U1(N)+U2(N))/2.	SMNT	78
	IF (UC1(N).EQ.0.0) GO TO 100	SMNT	79
C		SMNT	80
C	CALCULATES PROFILE DIFFERENCE	SMNT	81
C		SMNT	82
	DIFF=ABS(1.0-U2(N)/UC1(N))	SMNT	83
	IF (DIFF.GT.DIF) DIF=DIFF	SMNT	84
100	CONTINUE	SMNT	85
	UC1(N)=U2(N)	SMNT	86
110	CONTINUE	SMNT	87
	CALL DERIV3 (UC,XN,IE,1,UCN)	SMNT	88
	RETURN	SMNT	89
	END	SMNT	90

	SUBROUTINE SMOOTH (ZD,Z,R,NPTS,RF,RP,NU,RPP)	SMOO	1
C		SMOO	2
C	SMOOTHES DATA OVER 2*NU POINTS USING A	SMOO	3
C	WALKING LEAST-SQUARES CURVE FIT FOR $R = A*Z^{**B}$	SMOO	4
C		SMOO	5
C	RETURNS RF, RP AND RPP FROM ARRAY R	SMOO	6
C	CORRESPONDING TO ZD IN ARRAY Z	SMOO	7
C		SMOO	8
C	NPTS=NUMBER OF POINTS IN ARRAYS Z AND R	SMOO	9
C		SMOO	10
C	SUBROUTINE SMOOTH IS CALLED BY SUBROUTINES GEOM, AND INTRPS.	SMOO	11
C		SMOO	12
	DIMENSION A(10)	SMOO	13
	DIMENSION Z(NPTS), R(NPTS)	SMOO	14
C		SMOO	15
C		SMOO	16
10	CONTINUE	SMOO	17
	NP=NPTS	SMOO	18
	NS=NP-NU	SMOO	19
	DO 20 I=NU,NS	SMOO	20
	IF (ZD.GE.(Z(I)-1.0E-6).AND.ZD.LE.(Z(I+1)+1.0E-6)) GO TO 30	SMOO	21
C		SMOO	22
C	ASSUMES THAT Z(I) .LT. Z(I+1)	SMOO	23
C		SMOO	24
20	CONTINUE	SMOO	25
	NU=NU-1	SMOO	26
	IF (NU.GE.1) GO TO 10	SMOO	27
	STOP	SMOO	28
30	JF=I-NU+1	SMOO	29
	JL=I+NU	SMOO	30
	A(1)=JL-JF+1	SMOO	31
	DO 40 I=2,10	SMOO	32
40	A(I)=0.0	SMOO	33
	DO 50 I=JF,JL	SMOO	34
	A(2)=ALOG(R(I))	SMOO	35
	A(3)=A(3)+A(2)	SMOO	36
	A(4)=ALOG(Z(I))	SMOO	37
	A(5)=A(5)+A(4)	SMOO	38
	A(6)=A(6)+A(4)*A(4)	SMOO	39
50	A(7)=A(7)+A(4)*A(2)	SMOO	40
	A(8)=A(5)*A(5)-A(1)*A(6)	SMOO	41
	A(9)=A(5)*A(3)-A(1)*A(7)	SMOO	42
	A(10)=A(5)*A(7)-A(3)*A(6)	SMOO	43
	BB=A(9)/A(8)	SMOO	44
	AA=EXP(A(10)/A(8))	SMOO	45
	RF=AA*ZD**BB	SMOO	46

RP=AA*BB*ZD** (BB-1.0)	SMOD	47
RPP=AA*BB*(BB-1.0)*ZD** (BB-2.0)	SMOD	48
RETURN	SMOD	49
END	SMOD	50
	SMPR	1
C SUBROUTINE SMTHPR (S,YS,XX,YX,NPX,NNU)	SMPR	2
C SUBROUTINE SMTHPR INTERPOLATES FOR YS IN THE ARRAY YX	SMPR	3
C CORRESPONDING TO S IN THE ARRAY XX	SMPR	4
C SUBROUTINE SMTHPR CALLS SUBROUTINE INTRPS.	SMPR	5
C SUBROUTINE SMTHPR IS CALLED BY MAIN AND SUBROUTINE VPRFLE.	SMPR	6
C	SMPR	7
C DIMENSION XX(NPX), YX(NPX)	SMPR	8
C	SMPR	9
C NPX = NUMBER OF POINTS IN XX AND YX	SMPR	10
C	SMPR	11
C SMALL=1.0E-5	SMPR	12
C	SMPR	13
C	SMPR	14
C	SMPR	15
C	SMPR	16
C YMIN=100.	SMPR	17
C XMIN=100.	SMPR	18
C DO 10 N=1,NPX	SMPR	19
C IF (YMIN.GT.YX(N)) YMIN=YX(N)	SMPR	20
C IF (XMIN.GT.XX(N)) XMIN=XX(N)	SMPR	21
10 CONTINUE	SMPR	22
C	SMPR	23
C SHIFT COORDINATES	SMPR	24
C	SMPR	25
C IF (XMIN.LE.0.0) XMINX=ABS(XMIN)+SMALL	SMPR	26
C IF (YMIN.LE.0.0) YMINX=ABS(YMIN)+SMALL	SMPR	27
C IF (YMIN.GT.0.0) YMINX=0.0	SMPR	28
C IF (XMIN.GT.0.0) XMINX=0.0	SMPR	29
C XMIN=XMINX	SMPR	30
C YMIN=YMINX	SMPR	31
C DO 20 N=1,NPX	SMPR	32
C XX(N)=XX(N)+XMIN	SMPR	33
20 YX(N)=YX(N)+YMIN	SMPR	34
C S=S+XMIN	SMPR	35
C	SMPR	36
C INTERPOLATE	SMPR	37
C	SMPR	38
C CALL INTRPS (S,YS,XX,YX,NPX,NNU,DUM)	SMPR	39
C	SMPR	40
C RESHIFT COORDINATES	SMPR	41
C	SMPR	42
C S=S-XMIN	SMPR	43
C YS=YS-YMIN	SMPR	44
C DO 30 N=1,NPX	SMPR	45
C XX(N)=XX(N)-XMIN	SMPR	46
C YX(N)=YX(N)-YMIN	SMPR	47
30 CONTINUE	SMPR	48
C RETURN	SMPR	49
C END	SMPR	50

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C      SUBROUTINE SOLVE (W1,W2,E1,F1,CRNI,W2IE,CS1,CS2,SSFAC)          SOLV  1
C      SUBROUTINE SOLVE RETURNS THE SOLUTION OF PARABOLIC PARTIAL      SOLV  2
C      DIFFERENTIAL EQUATIONS IN STANDARD FORM                        SOLV  3
C      SUBROUTINE SOLVE CALLS SUBROUTINE DERIV3.                      SOLV  4
C      SUBROUTINE SOLVE IS CALLED BY SUBROUTINES ENERGY, SMOmnt, AND SOLV  5
C      SPECIE.                                                         SOLV  6
C      COMMON /SOLV/ A1(51),A2(51),A3(51),A4(51),DN(52),DS,XN(52),IE,IM SOLV  7
C      DIMENSION WINN(51), WIN(51), W1(51)                            SOLV  8
C      DIMENSION E(51), F(51), W2(51)                                SOLV  9
C      E(1)=E1                                                         SOLV 10
C      F(1)=F1                                                         SOLV 11
C      CALL DERIV3 (W1,XN,IE,1,WIN)                                   SOLV 12
C      CALL DERIV3 (WIN,XN,IE,1,WINN)                                 SOLV 13
C      DO 10 N=2,IM                                                    SOLV 14
C      CALCULATE RECURSION FORMULAS OUTWARD                          SOLV 15
C      A=(2.00-A1(N)*DN(N))/(DN(N-1)*(DN(N)+DN(N-1)))*CRNI          SOLV 16
C      B=(-2.0+A1(N)*(DN(N)-DN(N-1)))/(DN(N)*DN(N-1))+A2(N)*CRNI+A4(N)/SOLV 17
C      IDS                                                              SOLV 18
C      C=(2.00+A1(N)*DN(N-1))/(DN(N)*(DN(N)+DN(N-1)))*CRNI          SOLV 19
C      D=-(WINN(N)+A1(N)*WIN(N)+A2(N)*W1(N))*(1.00-CRNI)-A3(N)+A4(N)*W1(SOLV 20
C      1)/DS                                                            SOLV 21
C      E(N)=-C/(B+A*N*E(N-1))                                         SOLV 22
C      F(N)=(D-A*N*F(N-1))/(B+A*N*E(N-1))                             SOLV 23
C      IF (SSFAC) 30,30,20                                             SOLV 24
C      SK1=CS1+(DN(IM-1)+2.00*DN(IM))/(DN(IM)*(DN(IM)+DN(IM-1)))-(DN(IM-1)SOLV 25
C      1)+DN(IM))*E(IM)/(DN(IM-1)*DN(IM))-DN(IM)*(B*E(IM)+C)/(A*DN(IM-1)*(SOLV 26
C      2DN(IM)+DN(IM-1)))                                              SOLV 27
C      SK2=-CS2+(DN(IM-1)+DN(IM))*F(IM)/(DN(IM-1)*DN(IM))+DN(IM)*(B*F(IM)SOLV 28
C      1-D)/(A*DN(IM-1)*(DN(IM-1)+DN(IM)))                             SOLV 29
C      W2(IE)=SK2/SK1                                                  SOLV 30
C      GO TO 40                                                         SOLV 31
C      W2(IE)=W2IE                                                     SOLV 32
C      KCN=IM                                                           SOLV 33
C      DO 50 N=2,IE                                                    SOLV 34
C      CALCULATE FUNCTION INWARD                                       SOLV 35
C      W2(KON)=E(KON)*W2(KON+1)+F(KCN)                                SOLV 36
C      KCN=KON-1                                                       SOLV 37
C      RETURN                                                           SOLV 38
C      END                                                              SOLV 39

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C      SUBROUTINE SPECIE                                              SPEC  1
C      SUBROUTINE SPECIE SOLVES THE SPECIES EQUATIONS                SPEC  2
C      SUBROUTINE SPECIE CALLS SUBROUTINES ADJUST, DERIV3, AND SOLVE. SPEC  3
C      SUBROUTINE SPECIE IS CALLED BY MAIN.                           SPEC  4
C      COMMON /BODY/ HANGLE,XJFAC,IGECF,JFAC                         SPEC  5
C      COMMON /COMAR1/ XNSP(202),XSOL(200)                           SPEC  6
C      COMMON /COMAR1/ AA(51),BB(51),CAEQ(51),CON(51),COL(51),CO2(51),CPSSPEC  7
C      1T(51),EMBAR(51),PC(51),PCN(51),PE(51),PFAC(51),PS(51),PO(51),PON(51)SPEC  8
C      21),P1(51),PIN(51),P2(51),P2N(51),Q1(51),Q2(51),RC(51),RCON(51),RCSSPEC  9
C      3F(51),RNSH(51),RVISC(51),R1(51),R2(51),TC(51),T1(51),T2(51),T20(51)SPEC 10
C      4),T21(51),UC(51),UCN(51),UC1(51),U1(51),U2(51),U20(51),VC(51),VCD(SPEC 11
C      551),VC11(51),VC12(51),VG(51),VGN(51),VGS(51),VISC(51),VS(51),VO(51)SPEC 12
C      6),VON(51),V1(51),V2(51),V2N(51)                             SPEC 13
C      COMMON /COMDBL/ AJB(51,6),AJM(51,6),CC(51,6),CCL(51,6),CCN(51,6),CSPEC 14

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1PI(51,6),C1(51,6),C2(51,6),C20(51,6),DW(51,6),HI(51,6),WO(51,6),WISPEC 19
2(51,6) SPEC 20
COMMON /COMEDG/ CIE(6),TCIE SPEC 21
COMMON /COMFAC/ CCFAC,UFAC SPEC 22
COMMON /COMFSA/ CINF(6),CPIFS(6),DELHIF(6),HINF(6) SPEC 23
COMMON /COMG/ CAT,CNS,CRNI,REFAC,SSFAC,SWFAC,THIN,VPG,I,K,NITER SPEC 24
COMMON /COMG1/ CP,CPB,SP,SPB SPEC 25
COMMON /COMG2/ CK,CK2,CSF2,RS2,SIF2,XB2,XNSPM SPEC 26
COMMON /COMNS/ NS SPEC 27
COMMON /COMNS2/ NJ,NR,NSM1,NZ SPEC 28
COMMON /COMSML/ SMALLT SPEC 29
COMMON /COMSUM/ CPJSUM(51),HWSUM(51),HWSUM(51),HJSUMW SPEC 30
COMMON /COMTST/ DIFI(8),DIF,XU25 SPEC 31
COMMON /COMW/ CIW(6),CIWW(6),CPIW(6),HIW(6),HTFLB,TB,TCNW,TW SPEC 32
COMMON /INSH/ CONO,S,UPSH,XNS,EPS,TPSH,VISCO SPEC 33
COMMON /OUTSH/ PPS,PPS1,PPS2,PSP,REYSH,RRS,RRS1,RRS2,RSP,TSP,TTS,TSPEC 34
1TTS1,TTS2,USP,UUS,UUS1,UUS2,VSP,VVS,VVS1,VVS2 SPEC 35
COMMON /PRLE/ SIGM,XLE SPEC 36
COMMON /SOLV/ A1(51),A2(51),A3(51),A4(51),DN(52),DS,XN(52),IE,IM SPEC 37
C SPEC 38
C DIMENSION AJBN(51), AJPN(51) SPEC 39
C SPEC 40
C SMALL=1.0D-40 SPEC 41
C CMAX=1.00-SMALLT SPEC 42
C SPEC 43
C DO 80 J=1,NSM1 SPEC 44
C SPEC 45
C SOLVES FOR ONE LESS THAN THE NUMBER OF SPECIES SPEC 46
C SPEC 47
C DO 10 N=1,IE SPEC 48
C Q1(N)=AJB(N,J) SPEC 49
10 Q2(N)=AJM(N,J) SPEC 50
CALL DERIV3 (Q1,XN,IE,1,AJBN) SPEC 51
CALL DERIV3 (Q2,XN,IE,1,AJPN) SPEC 52
AJBN(1)=AJBN(2) SPEC 53
AJBN(IE)=AJBN(IM) SPEC 54
DO 20 N=1,IE SPEC 55
C SPEC 56
C CALCULATE COEFFICIENTS FOR PARTIAL DIFFERENTIAL EQUATIONS SPEC 57
C SPEC 58
A1(N)=REFAC*VISCO*(UUS*XNSP(I)*RNSH(N)*RC(N)*UC(N)*XN(N)/(VVS*CNS) SPEC 59
1-RCN(N)*VC(N))/AJB(N,J)+AJBN(N)/AJB(N,J)+CK*RNSH(N)+RCSF(N)*XJFAC SPEC 60
A2(N)=-REFAC*VISCO*CNS*RC(N)*W1(N,J)/(VVS*AJB(N,J)) SPEC 61
A3(N)=REFAC*VISCO*CNS*RC(N)*W2(N,J)/(VVS*AJB(N,J))+AJMN(N)/AJB(N,J) SPEC 62
1)+(AJM(N,J)/AJB(N,J))*(CK*RNSH(N)+XJFAC*RCSF(N)) SPEC 63
20 A4(N)=-REFAC*VISCO*UUS*RNSH(N)*RC(N)*UC(N)/(VVS*AJB(N,J)) SPEC 64
FAC=CONO*XLE/CPST(IE) SPEC 65
C SPEC 66
C CALCULATE SLIP VARIABLES SPEC 67
C SPEC 68
CS1=XNS*SP/(EPS*EPS*FAC) SPEC 69
CS2=-XNS*SP*CINF(J)/(EPS*EPS*FAC) SPEC 70
DO 30 N=1,IE SPEC 71
30 Q1(N)=C1(N,J) SPEC 72
IF (CAT) 40,40,50 SPEC 73
40 CCNTINUE SPEC 74
C SPEC 75
C NON-CATALYTIC WALL SPEC 76
C SPEC 77
E1=1.0 SPEC 78
F1=0.0 SPEC 79
GO TO 60 SPEC 80
50 CCNTINUE SPEC 81
C SPEC 82
C CATALYTIC WALL SPEC 83
C SPEC 84
E1=0.0 SPEC 85
F1=CIWW(J) SPEC 86
C SPEC 87
60 CALL SOLVE (Q1,Q2,E1,F1,CRNI,CINF(J),CS1,CS2,SSFAC) SPEC 88

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C	DO 70 N=1,IE	SPEC 89
	C2(N,J)=Q2(N)	SPEC 90
70	C1(N,J)=Q1(N)	SPEC 91
80	CONTINUE	SPEC 92
	DO 100 N=1,IE	SPEC 93
	CSUM=0.0	SPEC 94
	DO 90 J=1,NSM1	SPEC 95
90	CSUM=CSUM+C2(N,J)	SPEC 96
	C2(N,NS)=1.0-CSUM	SPEC 97
C		SPEC 98
C	LAST SPECIES FROM SUM OF NS-1 SPECIES	SPEC 99
C		SPEC 100
100	CONTINUE	SPEC 101
	DO 140 J=1,NS	SPEC 102
	DO 130 N=1,IE	SPEC 103
	IF (S.GE.0.0001) GO TO 120	SPEC 104
	IF (NS.EQ.6) GO TO 110	SPEC 105
	IF (NITER.GT.20) GO TO 110	SPEC 106
	C1(N,J)=C2(N,J)	SPEC 107
	GO TO 120	SPEC 108
110	CONTINUE	SPEC 109
	C1(N,J)=CCFAC*C1(N,J)+(1.0-CCFAC)*C2(N,J)	SPEC 110
120	CC(N,J)=(C1(N,J)+C2(N,J))/2.	SPEC 111
130	CONTINUE	SPEC 112
	CIH(J)=CC(1,J)	SPEC 113
	CIE(J)=CC(IE,J)	SPEC 114
140	CONTINUE	SPEC 115
	DO 160 J=1,NS	SPEC 116
	DO 150 N=2,IM	SPEC 117
C		SPEC 118
C	BOUND SPECIES	SPEC 119
C		SPEC 120
	IF (CC(N,J).LE.SMALL) CC(N,J)=SMALL	SPEC 121
	IF (CC(N,J).GT.CMAX) CC(N,J)=CMAX	SPEC 122
150	CONTINUE	SPEC 123
160	CONTINUE	SPEC 124
C		SPEC 125
	DO 190 J=1,NSM1	SPEC 126
	DO 170 N=1,IE	SPEC 127
170	Q1(N)=CC(N,J)	SPEC 128
	CALL DERIV3 (Q1,XN,IE,1,Q2)	SPEC 129
	DO 180 N=1,IE	SPEC 130
180	CCN(N,J)=Q2(N)	SPEC 131
190	CONTINUE	SPEC 132
	DO 240 N=1,IE	SPEC 133
C		SPEC 134
C	CALCULATE PRODUCT SUMS	SPEC 135
C		SPEC 136
	SUM1=0.00	SPEC 137
	SUM2=0.00	SPEC 138
	SUM3=0.00	SPEC 139
	SUM4=0.00	SPEC 140
	SUM5=0.00	SPEC 141
	DO 200 J=1,NSM1	SPEC 142
	SUM1=SUM1+CC(N,J)	SPEC 143
	SUM2=SUM2+CCN(N,J)	SPEC 144
	SUM3=SUM3+W0(N,J)	SPEC 145
	SUM4=SUM4+W1(N,J)*CC(N,J)	SPEC 146
	SUM5=SUM5+DW(N,J)	SPEC 147
200	CONTINUE	SPEC 148
	CC(N,NS)=1.00-SUM1	SPEC 149
	CCN(N,NS)=-SUM2	SPEC 150
	W0(N,NS)=-SUM3	SPEC 151
	W1(N,NS)=-SUM4/CC(N,NS)	SPEC 152
	DW(N,NS)=-SUM5	SPEC 153
	DO 220 J=1,NS	SPEC 154
	IF (CCL(N,J).EQ.0.00) GO TO 210	SPEC 155
	DIFF=ABS(1.00-CC(N,J)/CCL(N,J))	SPEC 156
	IF (DIFF.GT.DIFI(J+2)) DIFI(J+2)=DIFF	SPEC 157
		SPEC 158

210	CCNTINUE	SPEC 159
	CCL(N,J)=CC(N,J)	SPEC 160
220	CONTINUE	SPEC 161
	CPJSUM(N)=0.0	SPEC 162
	HDWSUM(N)=0.0	SPEC 163
	HWSUM(N)=0.0	SPEC 164
	DO 230 J=1,NS	SPEC 165
	CPJSUM(N)=CPJSUM(N)-CPI(N,J)*(AJM(N,J)+AJB(N,J)*CCN(N,J))/CNS	SPEC 166
	HCHSUM(N)=HDWSUM(N)+DW(N,J)*HI(N,J)	SPEC 167
230	HWSUM(N)=HWSUM(N)+(WO(N,J)-WI(N,J)*CC(N,J))*HI(N,J)	SPEC 168
240	CCNTINUE	SPEC 169
	HJSUMW=0.0	SPEC 170
	DO 250 J=1,NS	SPEC 171
250	HJSUMW=HJSUMW+HI(1,J)*(AJM(1,J)+AJB(1,J)*CCN(1,J))	SPEC 172
	RETURN	SPEC 173
	END	SPEC 174

	SUBROUTINE THERM (ISKI,BRAD,CCNC,VISCO,EPS,VIS2)	THRM 1
C		THRM 2
C	SUBROUTINE THERM CALCULATES THERMODYNAMIC PROPERTIES	THRM 3
C		THRM 4
C	SUBROUTINE THERM CALLS SUBROUTINES DERIV3, HCP, HCPA, VISCNA,	THRM 5
C	VISCON, AND WISUB.	THRM 6
C		THRM 7
C	SUBROUTINE THERM IS CALLED BY MAIN.	THRM 8
C		THRM 9
	COMMON /COMAR1/ AA(51),BB(51),CAEQ(51),CON(51),CO1(51),CO2(51),CPSTHRM	10
	1T(51),EMBAR(51),PC(51),PCN(51),PE(51),PFAC(51),PS(51),PO(51),POM(51)THRM	11
	21),P1(51),P1N(51),P2(51),P2N(51),Q1(51),Q2(51),RC(51),RCON(51),RCSTHRM	12
	3F(51),RNSH(51),RVISC(51),R1(51),R2(51),TC(51),T1(51),T2(51),T20(51)THRM	13
	4),T21(51),UC(51),UCN(51),UC1(51),U1(51),U2(51),U20(51),VC(51),VCD(THRM	14
	551),VCI1(51),VCI2(51),VG(51),VGN(51),VGS(51),VISC(51),VS(51),VO(51)THRM	15
	6),VON(51),V1(51),V2(51),V2N(51)	THRM 16
	COMMON /COMOBL/ AJB(51,6),AJM(51,6),CC(51,6),CCL(51,6),CCN(51,6),CTHRM	17
	1PI(51,6),C1(51,6),C2(51,6),C20(51,6),OW(51,6),HI(51,6),WO(51,6),W1THRM	18
	2(51,6)	THRM 19
	CCMMGN /COMFS/ PINF,REYN,RINF,TINF,UINF	THRM 20
	COMMON /COMFSA/ CINF(6),CPIFS(6),DELHIF(6),HINF(6)	THRM 21
	COMMON /COMNS/ NS	THRM 22
	COMMON /COMREF/ CONREF,CPREF,HREF,PREF,RREF,TREF,UREF,VSREF,WREF	THRM 23
	COMMON /COMVS/ EMI(6),VSA(6),VSB(6),VSC(6),R,NSPI(6)	THRM 24
	CCMMGN /COMW/ CIW(6),CIWW(6),CPIW(6),HIW(6),HTFLB,TB,TCNW,TW	THRM 25
	COMMON /OUTSH/ PPS,PPS1,PPS2,PSP,REYSH,RRS,RRS1,RRS2,RSP,TSP,TTS,THRM	26
	1TS1,TTS2,USP,UUS,UUS1,UUS2,VSP,VVS,VVS1,VVS2	THRM 27
	CCMMCN /PRLE/ SIGM,XLE	THRM 28
	CCMMGN /SOLV/ A1(51),A2(51),A3(51),A4(51),DN(52),DS,XN(52),IE,IM	THRM 29
C		THRM 30
	DIMENSION VST(51), CST(51), VISCN(51), CONN(51)	THRM 31
	DIMENSION HFAC(6)	THRM 32
C		THRM 33
	GO TC (10,30), ISKI	THRM 34
10	CONTINUE	THRM 35
	CAEQW=0.00	THRM 36
C		THRM 37
C	OXYGEN PROPERTIES- DAVIS AIAA PAPER	THRM 38
C		THRM 39
	EMI(1)=16.00	THRM 40
	EMI(2)=32.00	THRM 41
	B1=EXP(-11.692729)	THRM 42
	B2=EXP(-9.550244)	THRM 43
	B3=SQRT(8.00+8.00*EMI(1)/EMI(2))	THRM 44
C		THRM 45
	CO1=44.92777	THRM 46
	CO2=45.94634	THRM 47
	DO1=37.83461	THRM 48
	DO2=38.85627	THRM 49
	C11=59400.	THRM 50
	C12=59400.	THRM 51
	D11=0.0	THRM 52

	D12=0.00	THRM	53
	C21=-1.000	THRM	54
	C22=-1.000	THRM	55
	D21=-0.5000	THRM	56
	D22=-0.5000	THRM	57
C	CALL HCP (TINF,CPIFS,HINF,HFAC)	THRM	58
	HREF=UINF*UINF	THRM	59
C		THRM	60
C	FREESTREAM AND REFERENCE CONDITIONS	THRM	61
C		THRM	62
	EMBRFS=0.0	THRM	63
	CPINF=0.0	THRM	64
	DO 20 J=1,NS	THRM	65
	CPINF=CPINF+CPIFS(J)*CINF(J)	THRM	66
	EMBRFS=EMBRFS+CINF(J)/EMI(J)	THRM	67
20	CONTINUE	THRM	68
	EMBRFS=1.0/EMBRFS	THRM	69
	TREF=UINF*UINF/CPINF	THRM	70
	PINF=RINF*R*TINF/EMBRFS	THRM	71
	RREF=RINF	THRM	72
	UREF=UINF	THRM	73
	PREF=RINF*UINF*UINF	THRM	74
	CPREF=CPINF	THRM	75
	WREF=UINF/BRAD	THRM	76
C		THRM	77
	CALL VISCON (CINF,CPIFS,VSREF,AKAYRF,TREF)	THRM	78
	WRITE (6,130) VSREF	THRM	79
	CCNREF=VSREF*CPREF	THRM	80
C		THRM	81
C		THRM	82
	CALL VISCON (CINF,CPIFS,VSINF,AKAINF,TINF)	THRM	83
	WRITE (6,140) VSINF	THRM	84
	EPS=SQRT(VSREF/(RINF*UINF*BRAD))	THRM	85
	REYIN=RINF*UINF*BRAD/VSINF	THRM	86
	Th=TB/TREF	THRM	87
	GO TO 90	THRM	88
30	CCNTINUE	THRM	89
	VSMALL=1.0E-40	THRM	90
C		THRM	91
	CALL HCPA (TC,IE,HREF,CPREF,TTS,TREF,HI,CPI)	THRM	92
	IF (NS.NE.2) CALL VISCNA (TC,CC,CPI,IE,VST,CST,TTS,TREF,CPREF)	THRM	93
C		THRM	94
	DO 50 N=1,IE	THRM	95
C		THRM	96
C	REACTION RATES AND PRODUCTION TERMS FOR DISSOCIATING OXYGEN	THRM	97
C		THRM	98
	TST=TC(N)*TTS*TREF	THRM	99
	RST=RC(N)*RRS*RREF	THRM	100
	TK=TST/1.80	THRM	101
	RBAR=0.51536C*RST	THRM	102
	EKF1=EXP(CO1-C11/TK)*TK**C21	THRM	103
	IF (EKF1.LT.VSMALL) EKF1=VSMALL	THRM	104
	EKF2=EXP(CO2-C12/TK)*TK**C22	THRM	105
	IF (EKF2.LT.VSMALL) EKF2=VSMALL	THRM	106
	EKB1=EXP(DO1-D11/TK)*TK**D21	THRM	107
	EKB2=EXP(DO2-D12/TK)*TK**D22	THRM	108
	WODIM=RBAR*(0.50*(1.00-CC(N,1))*EKF1+CC(N,1)*EKF2)/EMI(1)	THRM	109
	WO(N,1)=WODIM/WREF	THRM	110
	WIDIM=WODIM+2.00*RBAR**2*CC(N,1)*(0.50*(1.00-CC(N,1))*EKB1+CC(N,1)*EKB2)/(EMI(1)*EMI(1))	THRM	111
	W1(N,1)=WIDIM/WREF	THRM	112
	DWDTK=RBAR*((1.00-CC(N,1))*(0.50*(1.00-CC(N,1))*EKF1*(-1.00*C21+C11/TK))+CC(N,1)*EKF2*(-1.00*C22+C12/TK))+2.00*RBAR*CC(N,1)**2*(0.50*(1.00-CC(N,1))*EKB1*(2.00-D21-D11/TK)+CC(N,1)*EKB2*(2.00-D22-D12/TK))/EMI(1)/TK	THRM	113
	DW(N,1)=UREF*BRAD*DWDTK/(CPREF*1.80)	THRM	114
	DW(N,2)=-DW(N,1)	THRM	115
	WO(N,2)=-WO(N,1)	THRM	116
	W1(N,2)=-W1(N,1)*CC(N,1)/CC(N,2)	THRM	117
	AEQ=0.50*(1.00-CAEQ(N))*EKF1+CAEQ(N)*EKF2	THRM	118
		THRM	119
		THRM	120
		THRM	121
		THRM	122
		THRM	123

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      IF (AEQ.LT.VSMALL) AEQ=VSMALL                                THRM 124
      BEQ=(0.50*(1.00-CAEQ(N))*EK81+CAEQ(N)*EK82)*2.00*RBAR/EMI(1) THRM 125
      ROOT=1.00+4.00*BEQ/AEQ                                       THRM 126
      IF (ROOT.LE.0.0) WRITE (6,100) AEQ,BEQ,CAEQ(N),RBAR,RC(N),RRS,RREF THRM 127
1,TST,TC(N),TTS,TREF                                              THRM 128
      CAEQ(N)=AEQ*(-1.00+SQRT(1.00+4.00*BEQ/AEQ))/(2.00*BEQ)      THRM 129
      IF (RST.LE.0.0) WRITE (6,110) RST,RC(N),RRS,RREF,PC(N),EMBAR(N) THRM 130
      IF (TST.LE.0.0) WRITE (6,120) TST,TC(N),TTS,TREF            THRM 131
C                                                                    THRM 132
C      PRDUCTION TERMS FOR MULTI-COMPONENT AIR                    THRM 133
C                                                                    THRM 134
      IF (NS.NE.2) CALL WISUB (RST,TST,N)                          THRM 135
C                                                                    THRM 136
      CPST(N)=0.0                                                  THRM 137
      SUM=0.0                                                       THRM 138
      DO 40 J=1,NS                                                  THRM 139
      SUM=SUM+CC(N,J)/EMI(J)                                        THRM 140
      CPST(N)=CPST(N)+CC(N,J)*CPI(N,J)                             THRM 141
40  CCNTINUE                                                       THRM 142
      EMBAR(N)=1.0/SUM                                             THRM 143
      IF (NS.NE.2) GO TO 50                                         THRM 144
C                                                                    THRM 145
C      VISCOSITY AND THERMAL CONDUCTIVITY FOR DISSOCIATING OXYGEN THRM 146
C                                                                    THRM 147
      CPA=CPI(N,1)*CPREF                                           THRM 148
      CPM=CPI(N,2)*CPREF                                           THRM 149
      VST1=B1*TK**(0.0184896*ALOG(TK)+0.4558107)                 THRM 150
      VST2=B2*TK**(0.0389680*ALOG(TK)+0.0094176)                 THRM 151
      B4=(1.00+SQRT(VST1/VST2))*(EMI(2)/EMI(1))**0.250)**2/B3    THRM 152
      VST(N)=(CC(N,1)*VST1/(EMI(1)*B4/EMI(2)+(1.00-EMI(1)*B4/EMI(2))*CC(N,1)) THRM 153
      1N,1)+(1.00-CC(N,1))*VST2/(1.00-(1.00-VST2*B4/VST1)*CC(N,1))*0.00 THRM 154
22088550                                                            THRM 155
      CON1=VST1*R*(CPA*EMI(1)/R+1.250)/EMI(1)                   THRM 156
      CON2=VST2*R*(CPM*EMI(2)/R+1.250)/EMI(2)                   THRM 157
      CST(N)=(CC(N,1)*CON1/(EMI(1)*B4/EMI(2)+(1.00-EMI(1)*B4/EMI(2))*CC(N,1)) THRM 158
      1N,1)+(1.00-CC(N,1))*CON2/(1.00-(1.00-VST2*B4/VST1)*CC(N,1))*0.00 THRM 159
22088550                                                            THRM 160
50  CCNTINUE                                                       THRM 161
      VISCO=VST(IE)/VSREF                                          THRM 162
      CONO=CST(IE)/CONREF                                          THRM 163
      DO 60 N=1,IE                                                  THRM 164
      VISC(N)=VST(N)/VST(IE)                                       THRM 165
      CCN(N)=CST(N)/CST(IE)                                         THRM 166
C                                                                    THRM 167
C      DIFFUSIONAL FLUX TERMS                                     THRM 168
C                                                                    THRM 169
      AJB(N,1)=CST(N)*XLE/(CPST(N)*CONREF)                       THRM 170
      AJB(N,2)=AJB(N,1)                                             THRM 171
      AJB(N,3)=AJB(N,1)                                             THRM 172
      AJB(N,4)=AJB(N,1)                                             THRM 173
      AJB(N,5)=AJB(N,1)                                             THRM 174
      AJB(N,6)=AJB(N,1)                                             THRM 175
      AJM(N,1)=0.0                                                  THRM 176
      AJM(N,2)=0.0                                                  THRM 177
      AJM(N,3)=0.0                                                  THRM 178
      AJM(N,4)=0.0                                                  THRM 179
      AJM(N,5)=0.0                                                  THRM 180
      AJM(N,6)=0.0                                                  THRM 181
60  CCNTINUE                                                       THRM 182
      CALL DERIV3 (VISC,XN,IE,1,VISCN)                            THRM 183
      CALL DERIV3 (CON,XN,IE,1,CCNN)                              THRM 184
      DO 70 N=2,IM                                                  THRM 185
      RVISC(N)=VISCN(N)/VISC(N)                                     THRM 186
      RCON(N)=CCNN(N)/CON(N)                                       THRM 187
70  CCNTINUE                                                       THRM 188
      RCON(1)=RCON(2)                                              THRM 189
      RCON(IE)=RCON(IM)                                             THRM 190
      RVISC(1)=RVISC(2)                                             THRM 191
      RVISC(IE)=RVISC(IM)                                           THRM 192
C                                                                    THRM 193
C      SHOCK REYNOLDS NUMBER                                       THRM 194

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C	REYSH=RINF*UINF*BRAD/VST(IE)	THRM 195
	TR=T2(1)*TTS2*TRF	THRM 196
C		THRM 197
	CALL HCP (TR,CPIW,HIW,HFAC)	THRM 198
	CALL VISCON (CIW,CPIW,VIS,AKAY,TR)	THRM 199
	VIS2=VIS/(VSREF*VISCO)	THRM 200
C		THRM 201
C	WALL CONDITIONS	THRM 202
C		THRM 203
C		THRM 204
	TK=TB/1.80	THRM 205
	RW=PC(1)*PPS/(TW*R*(1.00+CAEQW*(EMI(2)/EMI(1)-1.00))/(CPINF*EMI(2)	THRM 206
	1))	THRM 207
	TST=TB	THRM 208
	RST=RREF*RW	THRM 209
	RBAR=0.515360*RST	THRM 210
	EKF1=EXP(CO1-C11/TK)*TK**C21	THRM 211
	IF (EKF1.LT.VSMALL) EKF1=VSMALL	THRM 212
	EKF2=EXP(CO2-C12/TK)*TK**C22	THRM 213
	IF (EKF2.LT.VSMALL) EKF2=VSMALL	THRM 214
	EKB1=EXP(DO1-D11/TK)*TK**D21	THRM 215
	EKB2=EXP(DO2-D12/TK)*TK**D22	THRM 216
	CALL HCP (TST,CPIW,HIW,HFAC)	THRM 217
	HAW=HIW(1)/HREF	THRM 218
	HMW=HIW(2)/HREF	THRM 219
	AEQ=0.50*(1.00-CAEQW)*EKF1+CAEQW*EKF2	THRM 220
	IF (AEQ.LT.VSMALL) AEQ=VSMALL	THRM 221
	BEQ=(0.50*(1.00-CAEQW)*EKB1+CAEQW*EKB2)*2.00*RBAR/EMI(1)	THRM 222
	CAEQW=AEQ*(-1.00+SQRT(1.00+4.00*BEQ/AEQ))/(2.00*BEQ)	THRM 223
	HTFLB=CAEQW*HAW+(1.00-CAEQW)*HMW	THRM 224
	HW=0.0	THRM 225
	DO 80 J=1,NS	THRM 226
80	HW=HW+CIW(J)*HIW(J)/HREF	THRM 227
	IF (NS.NE.2) HTFLB=HW	THRM 228
90	CONTINUE	THRM 229
	RETURN	THRM 230
C		THRM 231
C		THRM 232
C		THRM 233
130	FCRMT (1HO,5X,3HAEQ,9X,3HBEQ,8X,4HCAEQ,8X,4HRBAR,8X,2HRC,10X,3HRR	THRM 234
	1S,9X,4HRRF,8X,3HTST,9X,2HTC,10X,3HTTS,9X,4HTREF, //1X,1PE12.4,1CE1	THRM 235
	22.4)	THRM 236
110	FURMT (1HO,5X,3HRST,9X,2HRC,10X,3HRRS,9X,4HRRF,8X,2HPC,10X,5HEMB	THRM 237
	1AR//1X,6E12.4)	THRM 238
120	FCRMT (1HO,5X,3HTST,9X,2HTC,10X,3HTTS,9X,4HTREF//1X,4E12.4)	THRM 239
130	FORMAT (1HO,7HVSREF =,E16.8)	THRM 240
140	FCRMT (10HO VSINF =,E16.8)	THRM 241
	END	THRM 242

C	FUNCTION TLU (NTABLE,Z,X,XSTAR,NFLAG)	TLU 1
C		TLU 2
C	FUNCTION TLU IS A ONE-DIMENSIONAL TABLE LOOK-UP PROGRAM.	TLU 3
C	CORRESPONDING VALUES OF X (ALWAYS INCREASING) AND Z ARE STORED	TLU 4
C	IN THE ARRAYS X(1)...X(NTABLE) AND Z(1)...Z(NTABLE). USING	TLU 5
C	LINEAR INTERPOLATION, THIS FUNCTION WILL GENERATE A VALUE OF Z	TLU 6
C	CORRESPONDING TO A SPECIFIED VALUE OF X = XSTAR.	TLU 7
C		TLU 8
C	FUNCTION TLU IS CALLED BY SUBROUTINE INTERP.	TLU 9
C		TLU 10
C	DIMENSION X(NTABLE), Z(NTABLE)	TLU 11
C		TLU 12
C		TLU 13
C CHECK TO SEE IF XSTAR LIES WITHIN THE SCOPE OF THE	TLU 14
C	TABULATED VALUES X(1)...X(NTABLE)	TLU 15
C		TLU 16
C	NFLAG=0	TLU 17

	IF (XSTAR.LT.X(1)) GO TO 10	TLU	18
	IF (XSTAR.LE.X(NTABLE)) GO TO 20	TLU	19
10	NFLAG=1	TLU	20
	TLU=0.0	TLU	21
	RETURN	TLU	22
C		TLU	23
C SEARCH TO FIND TWO SUCCESSIVE ENTRIES,	TLU	24
C	X(I-1) AND X(I), BETWEEN WHICH XSTAR LIES	TLU	25
C		TLU	26
20	I=1	TLU	27
30	IF (X(I).GT.XSTAR) GO TO 40	TLU	28
	IF (I.GE.NTABLE) GO TO 40	TLU	29
	I=I+1	TLU	30
	GO TO 30	TLU	31
C		TLU	32
C LINEARLY INTERPOLATE TO FIND CORRESPONDING VALUE OF Z	TLU	33
C		TLU	34
40	TLU=Z(I-1)+(XSTAR-X(I-1))*(Z(I)-Z(I-1))/(X(I)-X(I-1))	TLU	35
	RETURN	TLU	36
C		TLU	37
	END	TLU	38

	SUBROUTINE VISCNA (TC,CC,CPI,IE,VST,CST,TTS,TREF,CPREF)	VISA	1
C		VISA	2
C	SUBROUTINE VISCNA COMPUTES VISCOSITY (AMU) AND	VISA	3
C	CONDUCTIVITY (AKAY) FOR A TEMPERATURE ARRAY	VISA	4
C		VISA	5
C	SUBROUTINE VISCNA IS CALLED BY SUBROUTINE THERM.	VISA	6
C		VISA	7
	COMMON /COMNS/ NS	VISA	8
	COMMON /COMVS/ EMI(6),VSA(6),VSB(6),VSC(6),R,NSPI(6)	VISA	9
	DIMENSION VST(51), CST(51), TC(51), CC(51,6), CPI(51,6)	VISA	10
C		VISA	11
C		VISA	12
	DIMENSION CI(6), CPII(6)	VISA	13
C		VISA	14
	DIMENSION AMUI(6), XI(6)	VISA	15
C		VISA	16
C		VISA	17
	AMUFAC=2.205E-3/3.280833E-2/32.1750	VISA	18
C		VISA	19
C	AMUFAC CONVERTS AMUI FROM GM/(CM-SEC) TO LBF-SEC/FT**2	VISA	20
C		VISA	21
	DO 50 NN=1,IE	VISA	22
C		VISA	23
	DO 10 J=1,NS	VISA	24
	CI(J)=CC(NN,J)	VISA	25
	CPII(J)=CPI(NN,J)*CPREF	VISA	26
10	CONTINUE	VISA	27
	T=(TC(NN)*TTS*TREF)/1.80	VISA	28
C		VISA	29
	ALOGT=ALOG(T)	VISA	30
C		VISA	31
	DO 20 N=1,NS	VISA	32
	XI(N)=CI(N)/EMI(N)	VISA	33
20	AMUI(N)=EXP(VSC(N))*T**{(VSA(N)*ALOGT+VSB(N))*AMUFAC	VISA	34
	AMU=0.00	VISA	35
	AKAY=0.00	VISA	36
	DO 40 N=1,NS	VISA	37
	AKAYI=AMUI(N)/EMI(N)*(CPII(N)*EMI(N)/R+1.250)*R	VISA	38
	FAC=0.00	VISA	39
	DO 30 J=1,NS	VISA	40
	PHI=(1.00+SQRT(AMUI(N)/AMUI(J)))*(EMI(J)/EMI(N))*0.250)**2/SQRT(8.	VISA	41
	1)/(1.00+EMI(N)/EMI(J))*0.50	VISA	42
30	FAC=FAC+XI(J)*PHI	VISA	43
	FAC=XI(N)/FAC	VISA	44
	AML=AMU+AMUI(N)*FAC	VISA	45

40	AKAY=AKAY+AKAYI*FAC		VISA	46
	VST(NN)=AMU		VISA	47
	CST(NN)=AKAY		VISA	48
50	CONTINUE		VISA	49
C			VISA	50
C	UNITS OF CONDUCTIVITY	LBF/(SEC-DEG R)	VISA	51
C	UNITS OF VISCOSITY	LBF-SEC/FT**2	VISA	52
C			VISA	53
	RETURN		VISA	54
	END		VISA	55

	SUBROUTINE VISCON (CI,CPI,AMU,AKAY,TR)		VISC	1
C			VISC	2
C	SUBROUTINE VISCON COMPUTES VISCOSITY (AMU) AND		VISC	3
C	CONDUCTIVITY (AKAY) FOR A SINGLE TEMPERATURE		VISC	4
C			VISC	5
C	SUBROUTINE VISCON IS CALLED BY SUBROUTINES SHVALS, AND THERM.		VISC	6
C			VISC	7
	COMMON /COMNS/ NS		VISC	8
	COMMON /COMVS/ EMI(6),VSA(6),VSB(6),VSC(6),R,NSPI(6)		VISC	9
C			VISC	10
	DIMENSION CI(6), CPI(6)		VISC	11
C			VISC	12
	DIMENSION AMUI(6), XI(6)		VISC	13
C			VISC	14
C			VISC	15
	T=TR/1.80		VISC	16
	ALOGT=ALOG(T)		VISC	17
	AMUFAC=2.205E-3/3.280833E-2/32.1750		VISC	18
C			VISC	19
C	AMUFAC CONVERTS AMUI FROM GM/(CM-SEC) TO LBF-SEC/FT**2		VISC	20
C			VISC	21
	DO 10 N=1,NS		VISC	22
	XI(N)=CI(N)/EMI(N)		VISC	23
10	AMUI(N)=EXP(VSC(N))*T**((VSA(N)*ALOGT+VSB(N))*AMUFAC		VISC	24
	AMU=0.00		VISC	25
	AKAY=0.00		VISC	26
	DO 30 N=1,NS		VISC	27
	AKAYI=AMUI(N)/EMI(N)*(CPI(N)*EMI(N)/R+1.250)*R		VISC	28
	FAC=0.00		VISC	29
	DO 20 J=1,NS		VISC	30
	PHI=(1.00+SQRT(AMUI(N)/AMUI(J)))*(EMI(J)/EMI(N))**0.250)**2/SQRT(8.		VISC	31
	1)/(1.00+EMI(N)/EMI(J))**0.50		VISC	32
20	FAC=FAC+XI(J)*PHI		VISC	33
	FAC=XI(N)/FAC		VISC	34
	AMU=AMU+AMUI(N)*FAC		VISC	35
30	AKAY=AKAY+AKAYI*FAC		VISC	36
C			VISC	37
C	UNITS OF CONDUCTIVITY	LBF/(SEC-DEG R)	VISC	38
C	UNITS OF VISCOSITY	LBF-SEC/FT**2	VISC	39
C			VISC	40
	RETURN		VISC	41
	END		VISC	42

	SUBROUTINE VPRFLE (S,VP,V,IE,NTR,ICALL)	VPRF	1
C		VPRF	2
C	SUBROUTINE VPRFLE RETRIEVES THE NORMAL VELOCITY PROFILE	VPRF	3
C	FROM TAPE OR DISC STORAGE	VPRF	4
C		VPRF	5
C	SUBROUTINE VPRFLE CALLS SUBROUTINES INTERP, AND SMTHPR.	VPRF	6
C		VPRF	7
C	SUBROUTINE VPRFLE IS CALLED BY MAIN.	VPRF	8
C		VPRF	9
	COMMON /KNTR/ KNTR1,KNTW1,KNTW2	VPRF	10
	DIMENSION V(51), V1(51), ST(9), VST(9), VSPT(9), VT(51,9), DUM(8)	VPRF	11
	NPX=8	VPRF	12
	NNU=4	VPRF	13
	IF (ICALL.NE.1) GO TO 30	VPRF	14
	DO 20 N=1,NPX	VPRF	15
	READ (NTR) ST(N),VST(N),VSPT(N),V1	VPRF	16
	DO 10 K=1,IE	VPRF	17
10	VT(K,N)=V1(K)	VPRF	18
20	CONTINUE	VPRF	19
	KNTR1=KNTR1+NPX	VPRF	20
30	IF (S.LE.ST(NPX/2+1)) GO TO 80	VPRF	21
40	CONTINUE	VPRF	22
	IF (KNTR1.GE.KNTW2) GO TO 80	VPRF	23
	READ (NTR) ST(NPX+1),VST(NPX+1),VSPT(NPX+1),V1	VPRF	24
	KNTR1=KNTR1+1	VPRF	25
	DO 50 N=1,IE	VPRF	26
50	VT(N,NPX+1)=V1(N)	VPRF	27
	DO 70 N=1,NPX	VPRF	28
	ST(N)=ST(N+1)	VPRF	29
	VST(N)=VST(N+1)	VPRF	30
	VSPT(N)=VSPT(N+1)	VPRF	31
	DO 60 K=1,IE	VPRF	32
60	VT(K,N)=VT(K,N+1)	VPRF	33
70	CONTINUE	VPRF	34
	IF (S.GT.ST(NPX/2+1)) GO TO 40	VPRF	35
80	CONTINUE	VPRF	36
	CALL INTERP (S,ST,VSPT,NPX,VP)	VPRF	37
	DO 100 K=1,IE	VPRF	38
	DO 90 J=1,NPX	VPRF	39
90	DUM(J)=VT(K,J)	VPRF	40
	CALL SMTHPR (S,V(K),ST,DUM,NPX,NNU)	VPRF	41
100	CONTINUE	VPRF	42
	RETURN	VPRF	43
	END	VPRF	44
	SUBROUTINE WISUB (RHCN,T,N)	WISB	1
C		WISB	2
C	SUBROUTINE WISUB COMPUTES REACTION RATES WI/RHO AND THEIR	WISB	3
C	DERIVATIVES WITH RESPECT TO THETA	WISB	4
C		WISB	5
C	SUBROUTINE WISUB IS CALLED BY SUBROUTINE THERM.	WISB	6
C		WISB	7
	COMMON /COMABZ/ ALPHSB(15,11),BETASB(15,11),ZSUB(5,6),ALSUB(15),BEWISB	WISB	8
	ITSUB(15),GAMMMI(15,6),GAMMPL(15,6)	WISB	9
	COMMON /COMDBL/ AJB(51,6),AJM(51,6),CC(51,6),CCL(51,6),CCN(51,6),CWISB	WISB	10
	1PI(51,6),C1(51,6),C2(51,6),C20(51,6),DW(51,6),HI(51,6),WO(51,6),W1WISB	WISB	11
	2(51,6)	WISB	12
	COMMON /COMNS/ NS	WISB	13
	COMMON /COMNS2/ NJ,NR,NSM1,NZ	WISB	14
	COMMON /COMREF/ CONREF,CPREF,HREF,PREF,RRREF,TREF,UREF,VSREF,WREF	WISB	15
	COMMON /COMVS/ EMI(6),VSA(6),VSB(6),VSC(6),R,NSPI(6)	WISB	16
	COMMON /RTECON/ CRO(15),CR1(15),CR2(15),DRO(15),DR1(15),DR2(15)	WISB	17
C		WISB	18
	DIMENSION GAMMA(11), EKF(15), EKB(15), ELF(15), ELB(15)	WISB	19
C		WISB	20
	TK=T/1.80	WISB	21
	RHC=RHON	WISB	22
	RHCBR=.515360*RHO	WISB	23

	DO 10 I=1,NR	WISB 24
	EKF(I)=TK**CR2(I)*EXP(CRO(I)-CR1(I)/TK)	WISB 25
10	EKB(I)=TK**DR2(I)*EXP(DRO(I)-DR1(I)/TK)	WISB 26
C		WISB 27
	DC 20 J=1,NS	WISB 28
	GAMMA(J)=CC(N,J)/EMI(J)	WISB 29
	IF (GAMMA(J).LE.1.0E-20) GAMMA(J)=1.0E-20	WISB 30
20	CONTINUE	WISB 31
	IF (NZ) 30,60,30	WISB 32
30	NN=NS	WISB 33
	DO 50 I=1,NZ	WISB 34
	TERM1=0.0	WISB 35
	DO 40 J=1,NS	WISB 36
40	TERM1=TERM1+ZSUB(I,J)*GAMMA(J)	WISB 37
	NN=NN+1	WISB 38
50	GAMMA(NN)=TERM1	WISB 39
60	DO 110 I=1,NR	WISB 40
	TERM1=1.0	WISB 41
	TERM2=1.0	WISB 42
	DO 100 J=1,NJ	WISB 43
	IF (ALPHSB(I,J)) 70,80,70	WISB 44
70	TERM1=TERM1*GAMMA(J)**ALPHSB(I,J)	WISB 45
80	IF (BETASB(I,J)) 90,100,90	WISB 46
90	TERM2=TERM2*GAMMA(J)**BETASB(I,J)	WISB 47
100	CONTINUE	WISB 48
	ELF(I)=EKF(I)*RHOB**ALSUB(I)*TERM1	WISB 49
110	ELB(I)=EKB(I)*RHOB**BETSUB(I)*TERM2	WISB 50
	DO 130 I=1,NS	WISB 51
	TERM1=0.0	WISB 52
	TERM2=0.0	WISB 53
	TERM3=0.00	WISB 54
	DO 120 J=1,NR	WISB 55
	TERM1=TERM1+(GAMMPL(J,I)*ELF(J)+GAMMMI(J,I)*ELB(J))	WISB 56
	TERM2=TERM2+(GAMMPL(J,I)*ELB(J)+GAMMMI(J,I)*ELF(J))	WISB 57
	TERM3=TERM3+(GAMMPL(J,I)*ELB(J)+GAMMMI(J,I)*ELF(J))/GAMMA(I)	WISB 58
120	CONTINUE	WISB 59
	WO(N,I)=TERM1*EMI(I)/WREF	WISB 60
	WI(N,I)=TERM3/WREF	WISB 61
130	CCONTINUE	WISB 62
	DO 150 I=1,NS	WISB 63
	TERM1=0.0	WISB 64
	DC 140 J=1,NR	WISB 65
140	TERM1=TERM1+(BETASB(J,I)-ALPHSB(J,I))*((CR2(J)+CR1(J)/TK-ALSUB(J))	WISB 66
	I*ELF(J)-(DR2(J)+DR1(J)/TK-BETSUB(J))*ELB(J))	WISB 67
	DW(N,I)=TERM1*TREF*EMI(I)/(WREF*TK*1.80)	WISB 68
150	CONTINUE	WISB 69
	RETURN	WISB 70
	END	WISB 71
	BLOCK DATA	BLKD 1
	COMMON /COMEL/ ELN(6),ELO(6)	BLKD 2
	COMMON /COMFSA/ CINF(6),CPIFS(6),DELHIF(6),HINF(6)	BLKD 3
	COMMON /COMTAB/ CPTAB(50,6),HTAB(50,6),TMPTAB(50),NTAB	BLKD 4
	COMMON /COMVS/ EMI(6),VSA(6),VSB(6),VSC(6),R,NSPI(6)	BLKD 5
C		BLKD 6
C		BLKD 7
	DIMENSION TMTAB(49)	BLKD 8
	DIMENSION HTABO(49), HTABO2(49), HTABNO(49), HTABN(49), HTBNOP(49)	BLKD 9
	1, HTABN2(49)	BLKD 10
	DIMENSION CPTBO(49), CPTBO2(49), CPTBNO(49), CPTBN(49), CPNOPL(49)	BLKD 11
	1, CPTBN2(49)	BLKD 12
C		BLKD 13
	EQUIVALENCE (TMTAB(1),TMPTAB(1))	BLKD 14
C		BLKD 15
	EQUIVALENCE (CPTAB(1,1),CPTBO(1)), (CPTAB(1,2),CPTBO2(1)), (HTAB(1	BLKD 16
	1,1),HTABO(1)), (HTAB(1,2),HTABO2(1))	BLKD 17
C		BLKD 18


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EQUIVALENCE (HTAB(1,3),HTABNG(1)), (HTAB(1,4),HTABN(1)), (HTAB(1,5),HTABNO(1)), (HTAB(1,6),HTABN2(1))
11,5),CPNOPL(1)), (CPTAB(1,6),CPTBN2(1))
C DATA NSPI/4HO ,4HO2 ,4HNO ,4HN ,4HNO+ ,4HN2 /
C DATA DELHIF/.1661E+09,0.00,.3225E+08,.3619E+09,.35403E+09,0.00/
DATA ELO/1.00,2.00,1.00,0.00,1.00,0.00/
DATA ELN/2*0.00,3*1.00,2.00/
C DATA EMI/16.00,32.00,30.010,14.020,30.010,28.040/
C DATA VSA/.19558E-01,.38271E-01,.42501E-01,.85863E-02,.42501E-01,.48LKD
18349E-01/
DATA VSB/.4385110,.21076E-01,-.0188740,.64630,-.0188740,-.0224850/BLKD
DATA VSC/-11.62350,-9.59890,-9.61970,-12.5810,-9.61970,-9.98270/ BLKD
C DATA R/4.9686E4/
C DATA NTAB/49/
C DATA TMTAB/180.00000,900.00000,1260.00000,2700.00000,4140.00000,548LKD
100.00000,6660.00000,8100.00000,9540.00000,10800.00000,12060.00000,8LKD
213500.00000,14760.00000,16200.00000,17460.00000,18900.00000,20250.8LKD
300000,21600.00000,22950.00000,24300.00000,25650.00000,27000.00000,8LKD
428800.00000,30600.00000,32400.00000,34200.00000,36000.00000,37800.8LKD
500000,39600.00000,41400.00000,43200.00000,46800.00000,50400.00000,8LKD
654000.00000,57600.00000,61200.00000,64800.00000,68400.00000,72000.8LKD
700000,75600.00000,79200.00000,82800.00000,86400.00000,90000.00000,8LKD
893600.00000,97200.00000,100800.00000,104400.00000,108000.00000/ BLKD
DATA HTAB0/8253.71500,8279.54920,8172.09720,7984.16950,7916.94750,8LKD
17891.34800,7887.37350,7904.83620,7939.37050,7978.02000,8020.31550,8LKD
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38291.50390,8323.33120,8357.78720,8397.23470,8444.20880,8523.21350,8LKD
48626.56590,8759.82080,8927.42220,9132.17100,9375.02160,9654.78500,8LKD
59968.28450,10310.45050,11053.82080,11824.55870,12563.48510,13225.18LKD
62800,13782.82390,14227.41900,14562.59050,14799.52640,14952.70070,8LKD
75037.08810,15066.45870,15052.84530,15006.23110,14934.78420,14844.98LKD
89830,14741.95890,14629.70300,14511.31330/ BLKD
DATA CPTB0/8865.31690,7950.19860,7868.98760,7796.03850,7792.09530,8LKD
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812221.50690,11711.53610,11272.12040,10892.94790/ BLKD
DATA HTAB02/5442.28040,5525.27520,5660.18100,6144.76350,6446.82470BLKD
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8,6561.78750,6500.25340/ BLKD
DATA CPTB02/5442.78110,5814.05940,6167.59330,6834.31390,7184.23320BLKD
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5,7209.39450,7047.93480,6746.58460,6477.36880,6238.66470,6028.67400BLKD
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 8,7551.47660,7482.12830/ BLKD 92
 DATA CPTBN0/5803.88520,6030.56050,6361.44180,7129.76330,7370.99740BLKD 93
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 DATA CPTBN/8879.45150,8879.45150,8879.45150,8879.45150,8879.48720,8887.15460,8LKD 111
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 DATA HTBN0P/5803.34290,5817.96010,5871.11440,6255.80070,6558.14010BLKD 120
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 DATA HTABN2/6215.97350,6232.14830,6290.19010,6704.01580,7026.35980BLKD 138
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 END BLKD 156